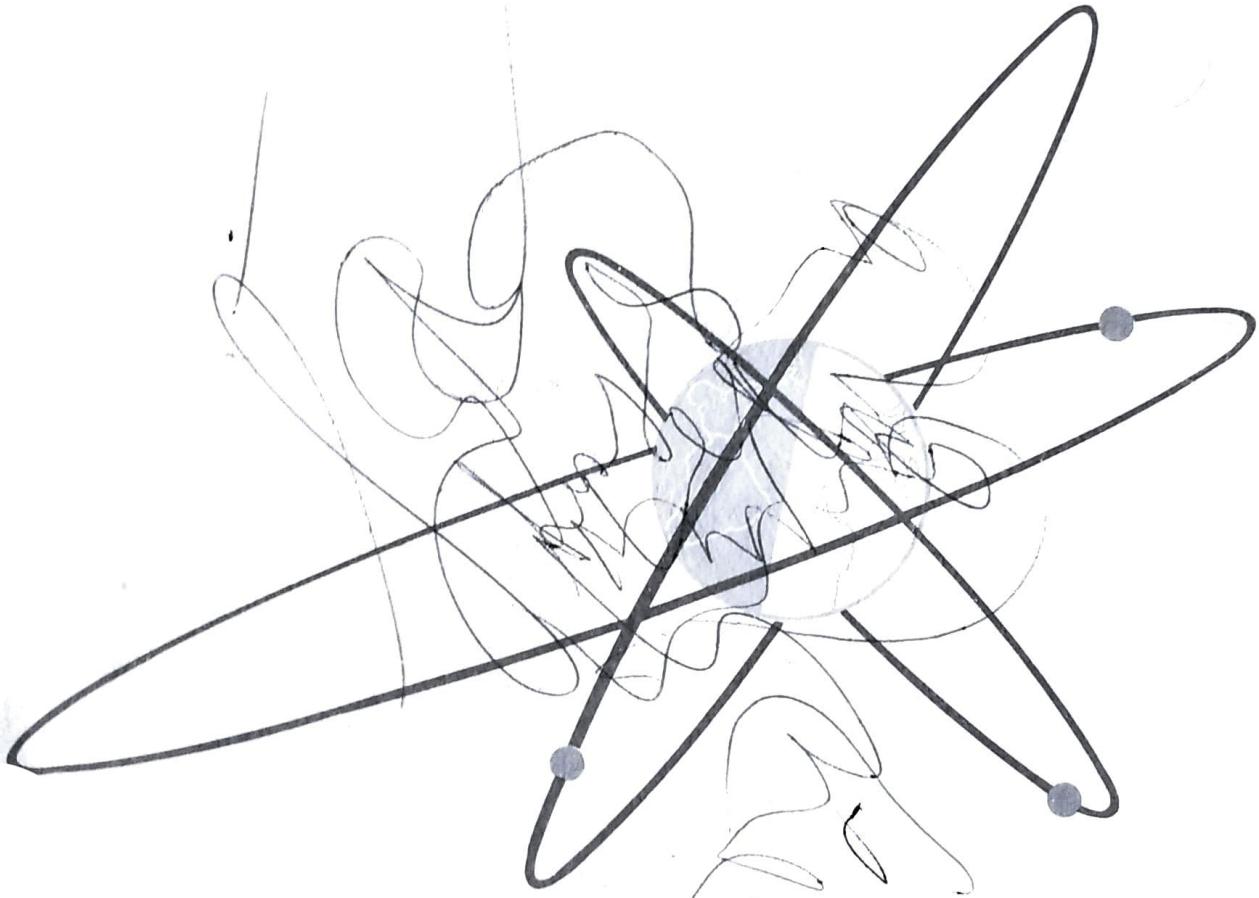
PRICE $2.00

HEATHKIT Jr®



ELECTRONIC WORKSHOP "35"

MODEL JK-18

HEATH COMPANY
BENTON HARBOR, MICHIGAN

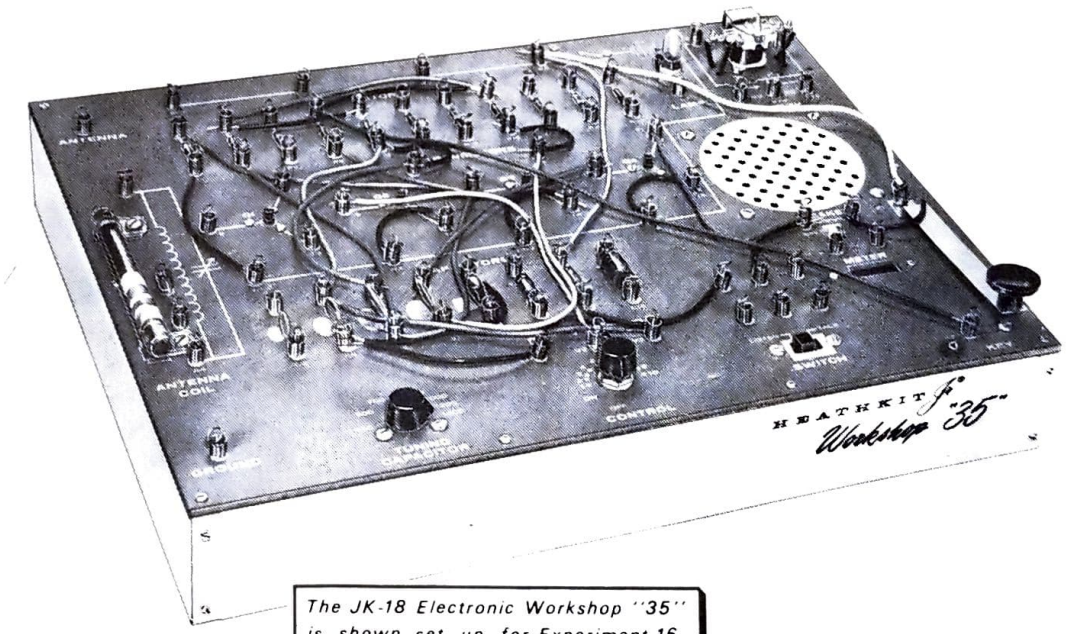
595-1068
6-6-69

The

HEATHKIT Jr®

ELECTRONIC WORKSHOP "35"

MODEL JK-18

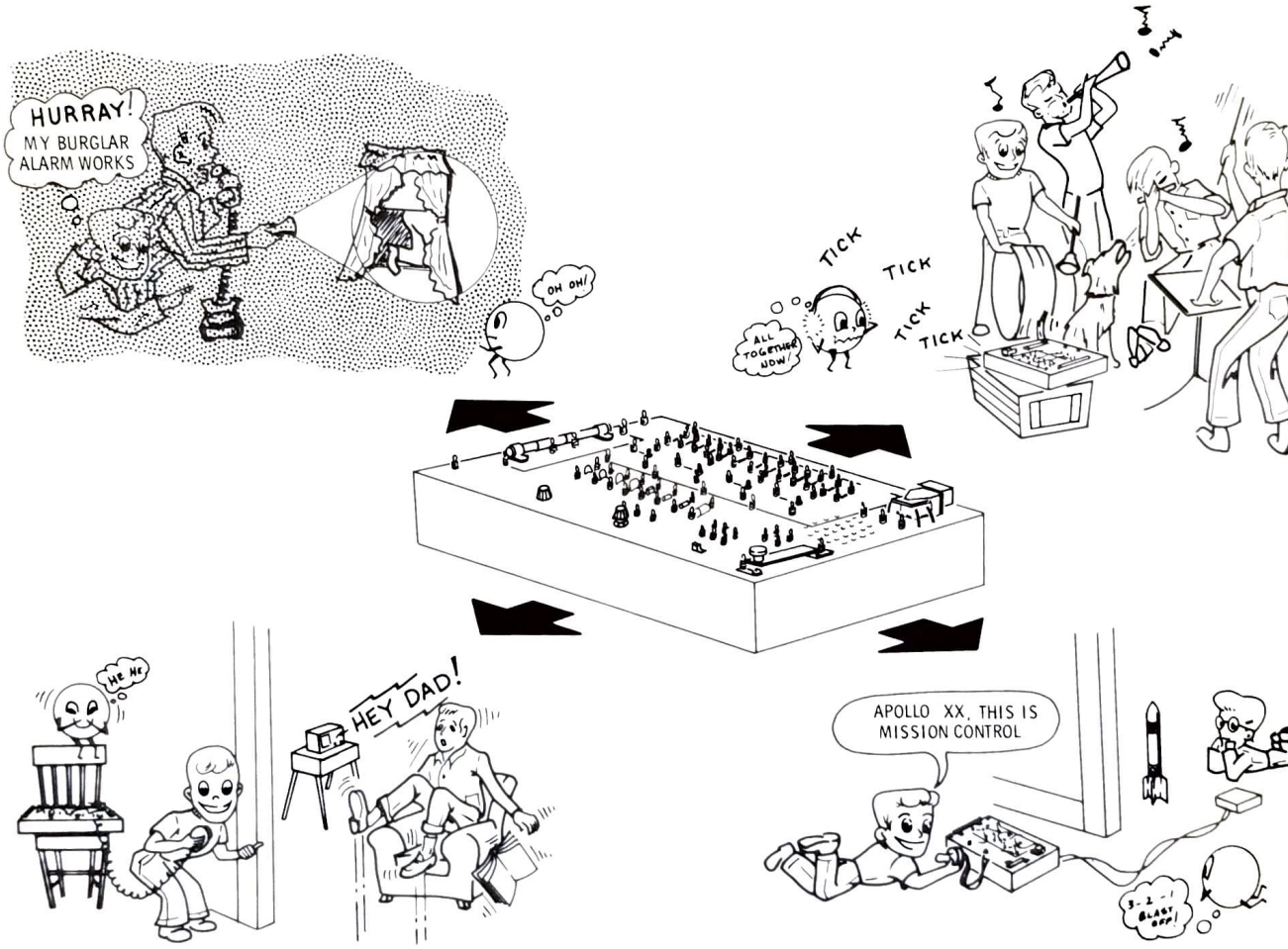


The JK-18 Electronic Workshop "35" is shown set up for Experiment 16, the Electronic Organ.

HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

TABLE OF CONTENTS

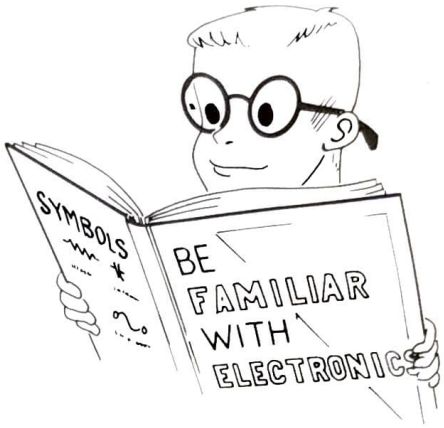
INTRODUCTION



Your Heathkit JR.® JK-18 Electronic Workshop "35" lets you learn about electronics and have fun at the same time. It has thirty-five different Experiments, ranging from a simple Code Flasher to a Capacitor Bridge. After you put the Workshop together, just attach a few snap-in wires and you can have a Radio, an Electronic Organ, a Burglar Alarm, or many other interesting devices. You can also learn the symbol for each part, how to understand a circuit diagram, and how each circuit works.

Step-By-Step instructions make the Workshop easy to assemble, and the workshop board is drilled and marked for each part. All wires are cut and ready to use. Each Experiment includes a Wiring Chart and a clear drawing of the workshop board with all the wires snapped in place. Almost any Experiment can be ready to operate in only 10 or 20 minutes.

The Experiments will help you become familiar with electronics. A simple explanation is given for each part you use, with a drawing of the part and its symbol. Then the symbols are connected together in a circuit diagram (or "schematic") that tells you how the circuit works. Additional information about parts is given in the Dictionary (Pages 159 to 161). Simple Experiments are given first.



This Electronic Workshop will introduce you to many new ideas, and could open up a whole new future for you. An interest in electronics could help you get started in an exciting hobby like amateur radio or radio-controlled models. It might even be the beginning of a future career for you in electronics. If this interest grows as you perform Experiments, and you want to learn more, refer to "How to Learn More About Electronics" (Page 163).

WORKSHOP "35" ASSEMBLY

PARTS LIST

To order replacement parts, refer to the Replacement Parts Price List and use the Parts Order Form furnished with this kit.

Unpack your kit carefully and check each part against the following Parts List. The numbers in parentheses match the numbered parts on the Parts Pictorial.

Before assembling your Workshop, read the Kit Builders Guide. Pages 6 and 7 will tell you how to identify parts, Pages 14 and 15 tell about the Services Heath has to help you, and Page 16 has the Warranty for your Workshop. The other pages furnish general information about wired Heathkits.

PART No.	PARTS Per Kit	DESCRIPTION
RESISTORS		
Identify each resistor by the color bands.		
(1) 1-83	1	56 Ω (green-blue-black)
1-6	1	470 Ω (yellow-violet-brown)
1-7	1	680 Ω (blue-gray-brown)
1-9	1	1000 Ω (brown-black-red)
1-16	1	4700 Ω (yellow-violet-red)
1-73	1	8200 Ω (gray-red-red)
1-20	1	10 kΩ (brown-black-orange)
1-22	1	22 kΩ (red-red-orange)
1-26	1	100 kΩ (brown-black-yellow)
1-27	1	150 kΩ (brown-green-yellow)
1-30	1	270 kΩ (red-violet-yellow)
CAPACITORS		
The capacitor value is printed on the body of each capacitor. Capacitors may be MF or MFD instead of μF.		
(2) 21-140	1	.001 μF
21-46	1	.005 μF
21-16	1	.01 μF
21-31	1	.02 μF
21-48	1	.05 μF
(3) 27-47	2	.1 μF
(4) 25-54	2	10 μF
25-56	1	100 μF
(5) 26-67	1	Tuning capacitor
OTHER CIRCUIT COMPONENTS		
(6) 417-118	4	Transistor (type 2N3393)
(7) 9-6	1	LDR (light dependent resistor)*
(8) 401-36	1	Earphone
(9) 40-984	1	Antenna coil
(10) 19-83	1	Control
(11) 60-2	1	Slide switch
(12) 75-52	1	Switch insulator
(13) 69-15	1	Relay
(14) 401-137	2	Speaker
(15) 407-116	1	Meter
(16) 412-1	1	Lamp
(17) 434-21	1	Socket

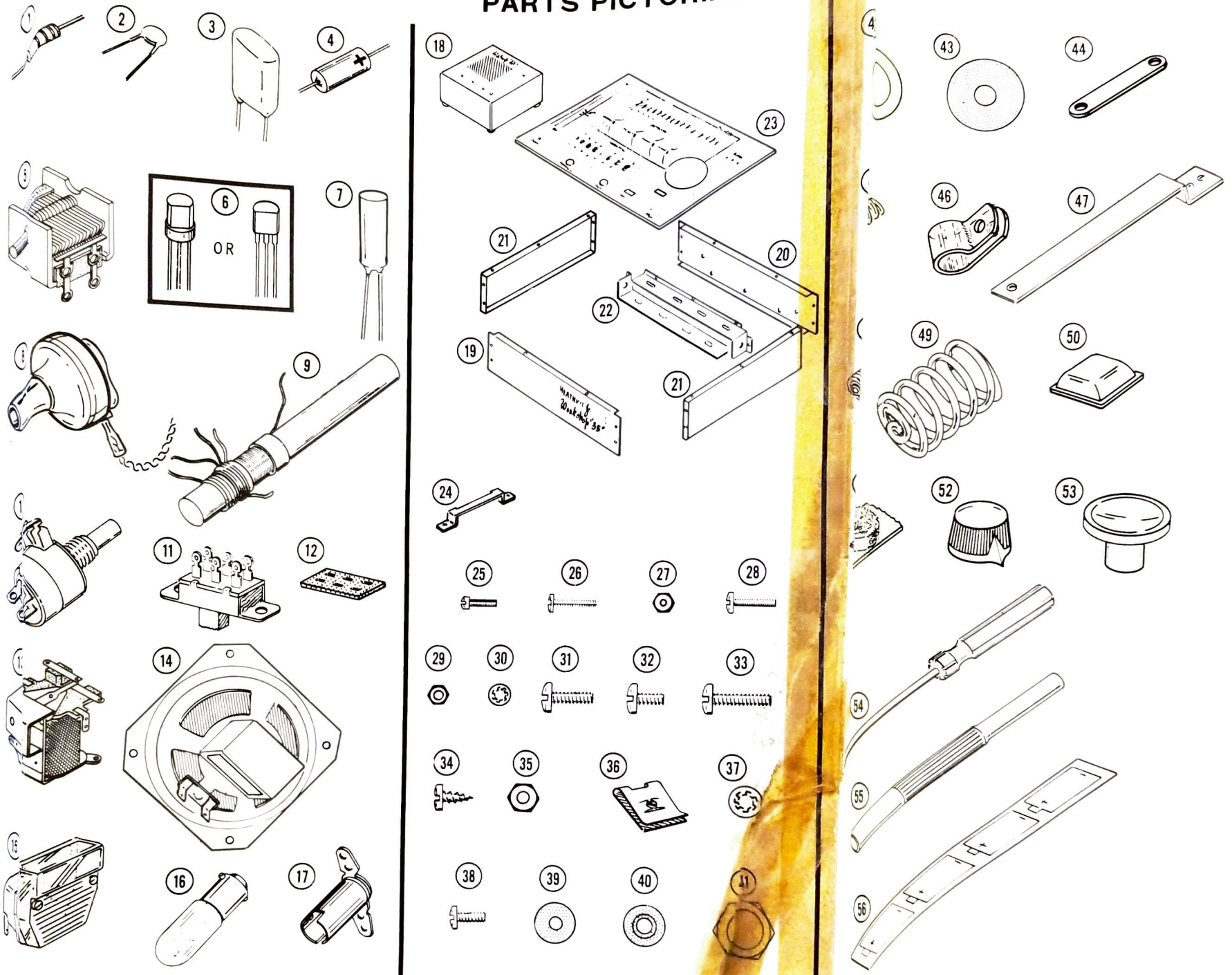
*NOTE: Place the LDR (light dependent resistor) with the earphone in the plastic pouch.

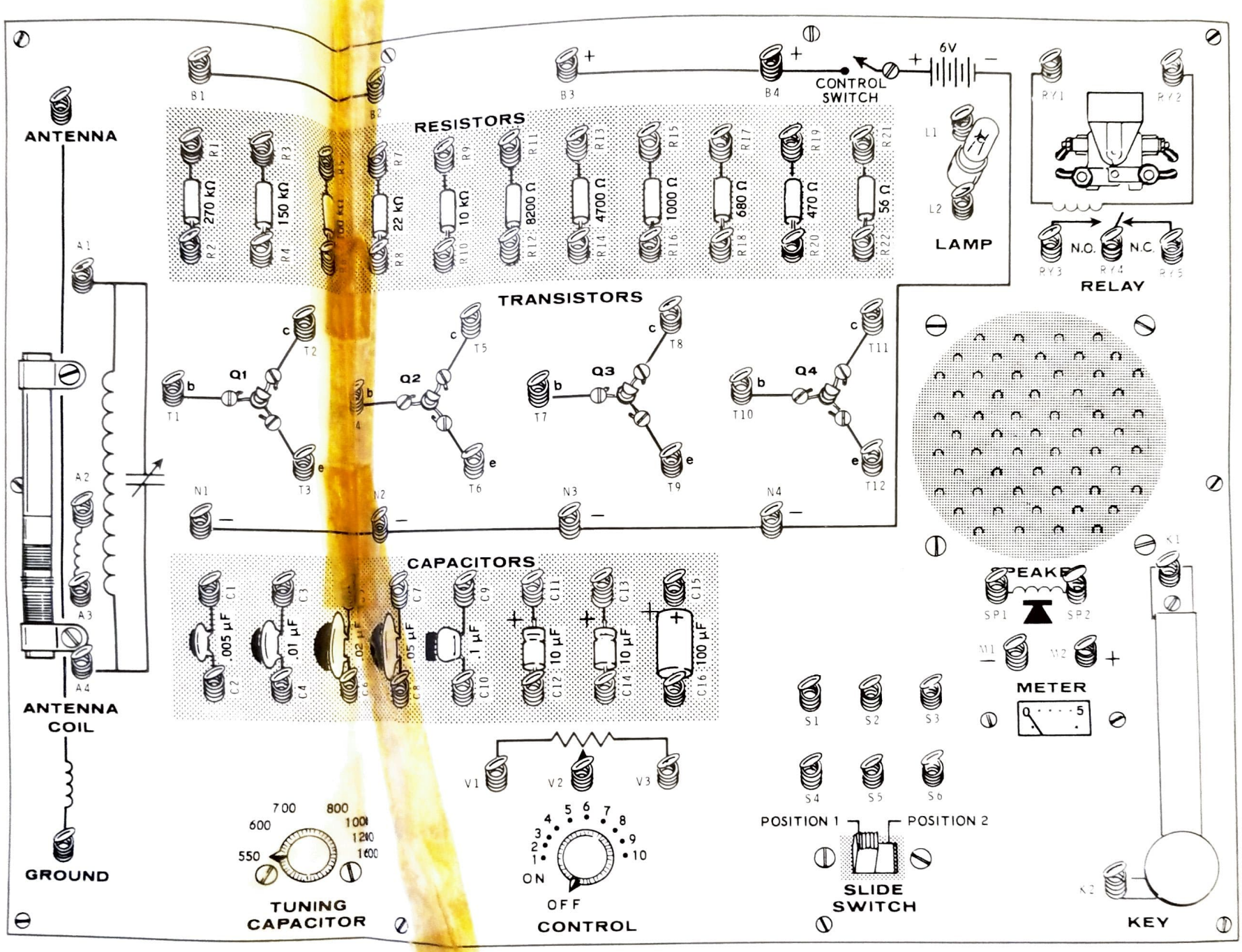
PART No.	PARTS Per Kit	DESCRIPTION
METAL PARTS		
(18) 200-544	1	Remote chassis
(19) 202-83	1	Front panel
(20) 202-84	1	Rear panel
(21) 202-85	2	Side panel
(22) 204-946	2	Battery bracket
(23) 86-18-1	1	Workshop board
(24) 204-922	1	Meter bracket
HARDWARE		
Each piece of hardware is shown in its actual size on the Parts Pictorial.		
#2 Hardware (in Envelope #171-2478)		
(25) 250-182	5	2-56 x 1/4" screw
(26) 250-175	7	2-56 x 3/8" screw
(27) 252-51	13	2-56 nut
#3 Hardware (in Envelope #171-2477)		
(28) 250-172	122	3-48 x 3/8" screw (2 extra)
(29) 252-1	122	3-48 nut (2 extra)
(30) 254-7	62	#3 lockwasher (2 extra)
#6 Hardware (in Envelope #171-2476)		
(31) 250-89	9	6-32 x 3/8" screw
(32) 250-56	15	6-32 x 1/4" screw (2 extra)
(33) 250-162	3	6-32 x 1/2" screw
(34) 250-170	8	#6 sheet metal screw
(35) 252-3	13	6-32 nut (2 extra)
(36) 252-22	8	#6 speednut
(37) 254-1	7	#6 lockwasher
Other Hardware (in Envelope #171-2479)		
(38) 250-52	2	4-40 x 1/4" screw
(39) 253-1	4	Fiber flat washer
(40) 253-2	5	Fiber shoulder washer

PART No.	PARTS Per Kit	DESCRIPTION
Other Hardward (cont'd.)		
(41) 252-7	1	Control nut
(42) 253-10	1	Control washer
(43) 253-6	1	Large fiber washer
(44) 212-14	14	Jumper strip
(45) 258-47	12	Lug connector spring
WIRE		
100-849	1	Wire pack
consisting of:		
	40	3" black
	20	4" brown
	18	6" red
	7	8" orange
	4	10" yellow
	4	12" black
	3	14" brown
	1	25' (25 ft) white-blue
	1	25' (25 ft) white
	1	9" bare
MISCELLANEOUS		
(46) 207-19	2	Cable clamp
(47) 258-37	2	Key
(48) 258-38	90	Connector spring
(49) 258-43	1	Battery spring
(50) 261-29	1	Plastic foot
(51) 263-7	8	Felt foot
(52) 462-17	2	Pointer knob
(53) 462-105	2	Knob
(54) 490-25	1	Screwdriver
(55) 490-5	1	Nut starter
(56) 390-257	1	Battery label
597-472	1	FCC Certification Form
597-308	1	Kit Builders Guide
597-260	1	Parts Order Form
391-34	1	Blue and white label
	1	Manual (See front cover for part number.)

NOTE: You will also need four size "D" flashlight batteries for your Workshop. Do not buy mercury type batteries.

PARTS PICTORIAL





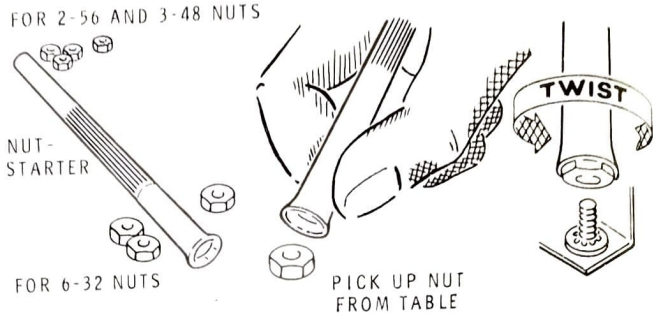
PICTORIAL 1A

ASSEMBLY NOTES

In the following steps, you will permanently mount all of the parts except the LDR (light dependent resistor) and earphone. Be careful that you do not damage components by applying excess strain on the wire leads.

A small screwdriver is supplied with this kit to help you mount parts. A plastic nut starter is also given to help you hold and start nuts on screws.

Be sure to read each step all of the way thru before you start to do what it tells you. Then make a check mark in the space provided (✓).



STEP-BY-STEP ASSEMBLY

Refer to Pictorial 1A (fold-out from Page 8) and to Pictorial 1B (fold-out from Page 23) as you assemble the Workshop in the following steps.

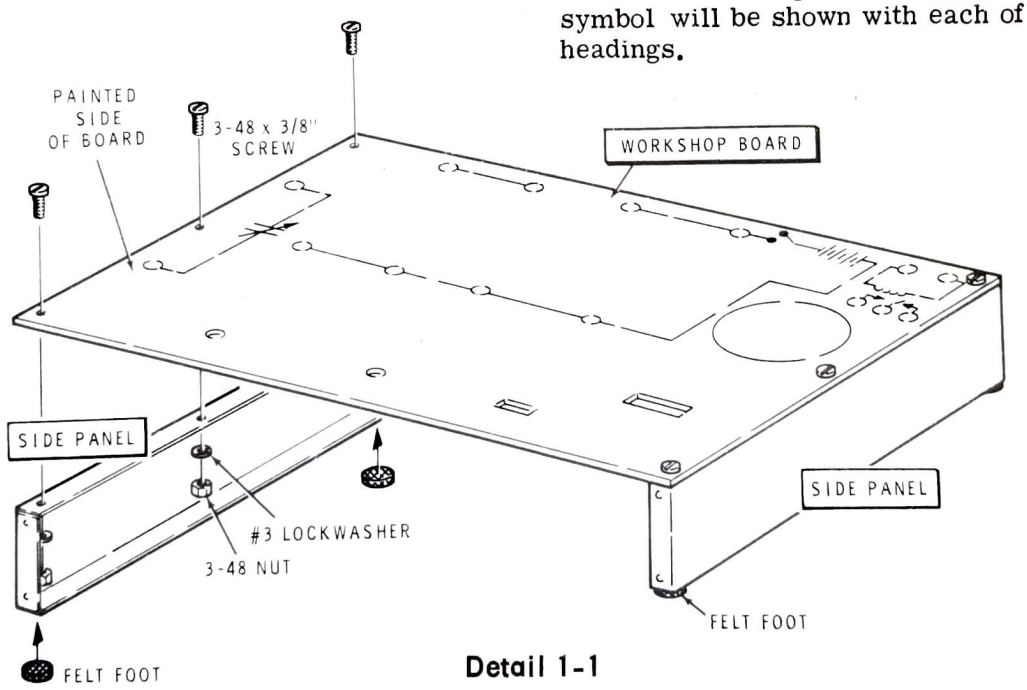
NOTE: When you mount the workshop board on one of the base panels, as in the next step, first start all of the screws in that panel. Then go back and tighten the screws.

(✓) Refer to Detail 1-1 and mount a side panel to the workshop board. Use 3-48 x 3/8" screws, #3 lockwashers, and 3-48 nuts.

(✓) In a similar manner, mount the other side panel.

(✓) Install the four felt feet, one at a time, by removing the backing paper and installing them as shown.

NOTE: A drawing of the part and its electrical symbol will be shown with each of the following headings.



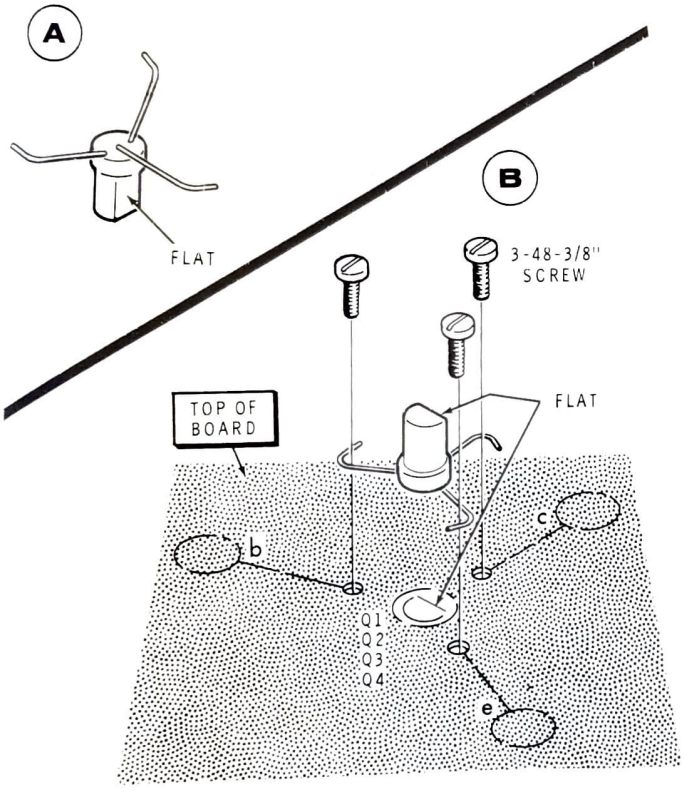
Detail 1-1

TRANSISTORS

( ) Spread the leads of the four transistors as shown in part A of Detail 1-2.

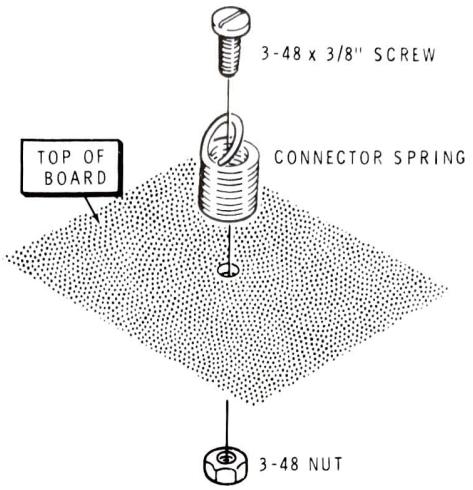
NOTE: When you connect a lead (or wire) to a screw, always wrap it around the screw in a clockwise direction (the way a clock's hands turn).

( ) Refer to part B of Detail 1-2 and install transistors at Q1, Q2, Q3, and Q4. Use three 3-48 x 3/8" screws with each transistor. Bend the leads around the screws. The nuts will be installed later. Be sure to position the flat side of each transistor as shown.



Detail 1-2

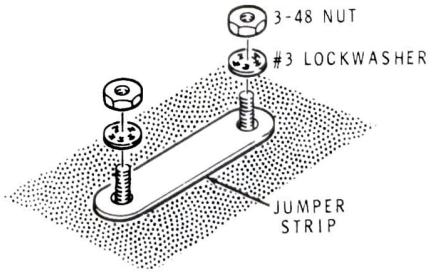
NOTE: To mount a connector spring, insert a 3-48 x 3/8" screw thru the opening as shown in Detail 1-3. Then turn the screw into the board until it is firmly in place. Do not install a nut unless you are directed to in the step.



Detail 1-3

( ) Install connector springs at locations T1 thru T12.

( ) Refer to Detail 1-4 and Pictorial 1B. Then install the twelve jumper strips as shown at Q1, Q2, Q3, and Q4. Use #3 lockwashers and 3-48 nuts. Tighten the screws securely. Be sure the transistor leads are under the screw heads.



Detail 1-4

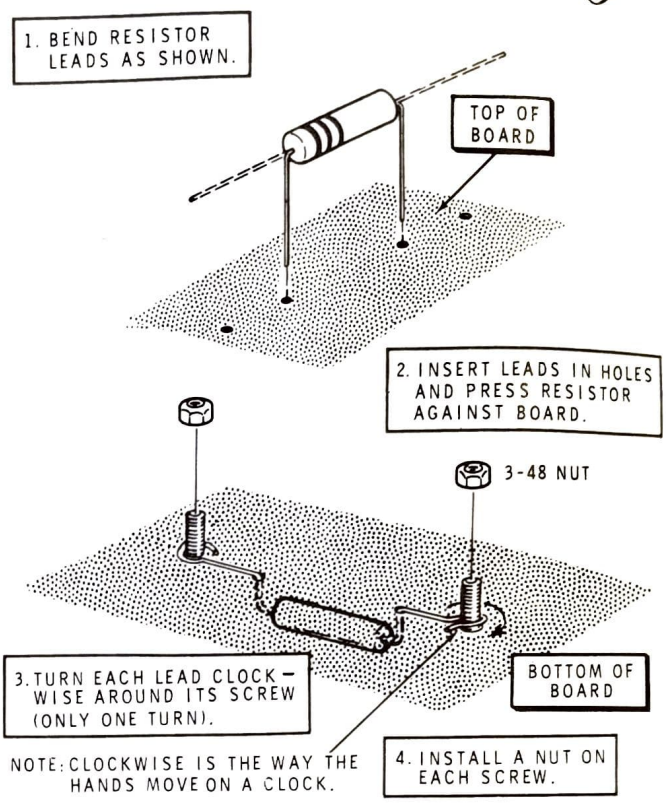
RESISTORS 

( ) Install connector springs at locations R1 thru R22.

Install resistors on the board as directed in the following steps and as shown in Detail 1-5. Position the color bands near the even-numbered connectors (R2, R4, etc.).

NOTE: When you install nuts over wires, always hold the nut and tighten the screw. This will keep the nut from pulling the lead and damaging the part.

RESISTORS	FROM	TO
( ) 270 kΩ (red-violet-yellow)	R2	R1
( ) 150 kΩ (brown-green-yellow)	R4	R3
( ) 100 kΩ (brown-black-yellow)	R6	R5
( ) 22 kΩ (red-red-orange)	R8	R7
( ) 10 kΩ (brown-black-orange)	R10	R9
( ) 8200 Ω (gray-red-red)	R12	R11
( ) 4700 Ω (yellow-violet-red)	R14	R13
( ) 1000 Ω (brown-black-red)	R16	R15

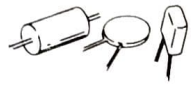


Detail 1-5

RESISTORS	FROM	TO
( ) 680 Ω (blue-gray-brown)	R18	R17
( ) 470 Ω (yellow-violet-brown)	R20	R19
( ) 56 Ω (green-blue-black)	R22	R21

( ) Position the resistor leads so they do not touch each other, or cut off excess lead lengths.

CAPACITORS



( ) Install connector springs at locations C1 thru C16.

Install the capacitors on the board as directed in the following steps. Install them just like you installed the resistors.

CAPACITOR	FROM	TO
( ) .005 μF	C2	C1
( ) .01 μF	C4	C3
( ) .02 μF	C6	C5
( ) .05 μF	C8	C7
( ) .1 μF	C10	C9

NOTE: Each of the next three capacitors has a positive (+) sign near one end. Be sure to position the lead from this end as shown, to the odd-numbered connector (C11, C13, or C15).

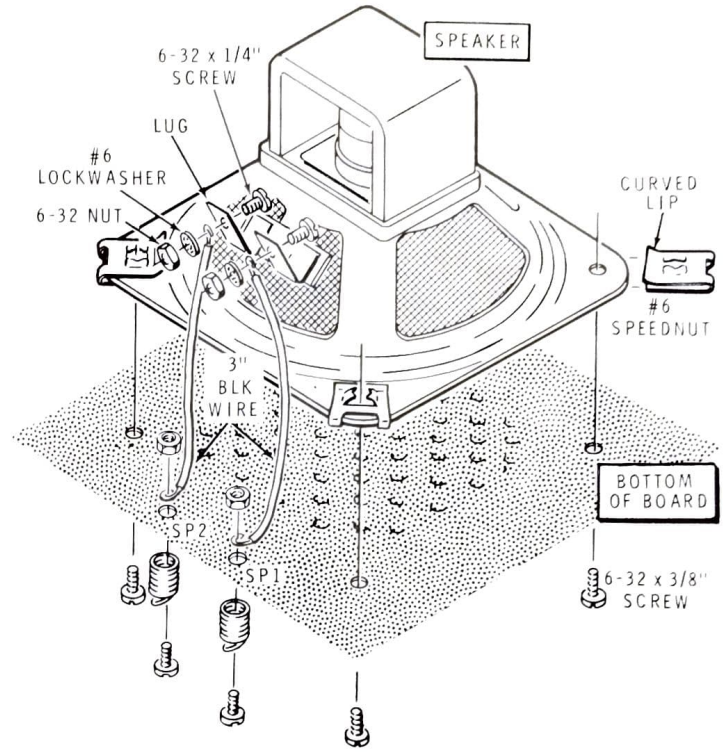
( ) 10 μF	C12	(+) C11
( ) 10 μF	C14	(+) C13
( ) 100 μF	C16	(+) C15

( ) Position the capacitor leads so they do not touch each other, or cut off excess lead lengths.

The three remaining capacitors will be connected later.

SPEAKER

NOTE: Remove your watch before working with the speaker. The magnet in the speaker can magnetize some watches and affect their operation. Handle the speaker with care. Be especially careful that you do not puncture the paper cone.



Detail 1-6

( ) Refer to Detail 1-6 and push a speednut on each corner hole of the speaker. The curved lip should be up, as shown.

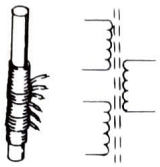
( ) Position the speaker with the lugs as shown in Pictorial 1B. Then mount the speaker on the board with four 6-32 x 3/8" screws.

( ) Connect a 3" black wire to each speaker lug with a 6-32 x 1/4" screw and a 6-32 nut.

( ) Mount connector springs at SP1 and SP2.

( ) Connect one black speaker wire to SP1 and the other black speaker wire to SP2. Then tighten the screws at SP1 and SP2.

ANTENNA COIL



( ) Refer to Detail 1-7 and slide a cable clamp onto each end of the antenna coil. Position the clamps as shown. Excess wax may be scraped off the end of the antenna, if necessary, for a better fit.

( ) Refer to Detail 1-8, position the coil as shown, and insert each wire into its hole.

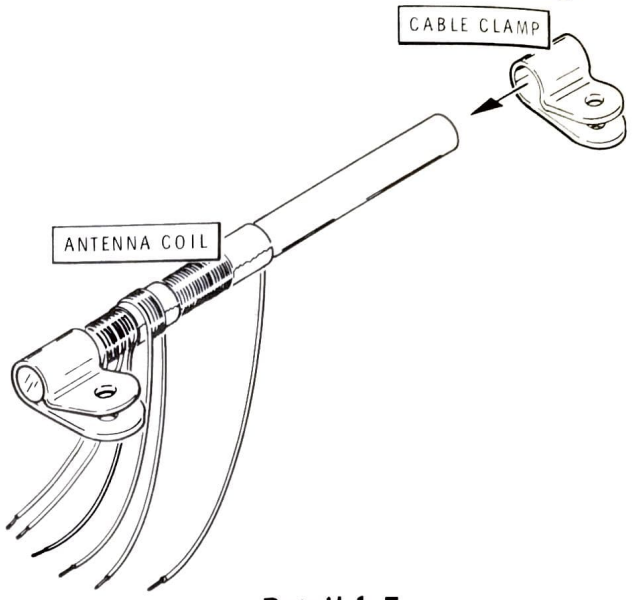
( ) Mount the clamps to the workshop board with 6-32 x 1/2" screws and 6-32 nuts.

( ) Mount connector springs at "Antenna", A1, A2, A3, A4, and "Ground."

( ) Refer to Pictorial 1B and connect the white wire coming from hole 6 to the screw at Ground. Install a 3-48 nut and tighten the screw.

( ) Connect the white wire coming from hole 5 to the screw at Antenna. Install a 3-48 nut and tighten the screw.

( ) Connect the white-red wire coming from hole 3 to screw A3. Do not install a nut.

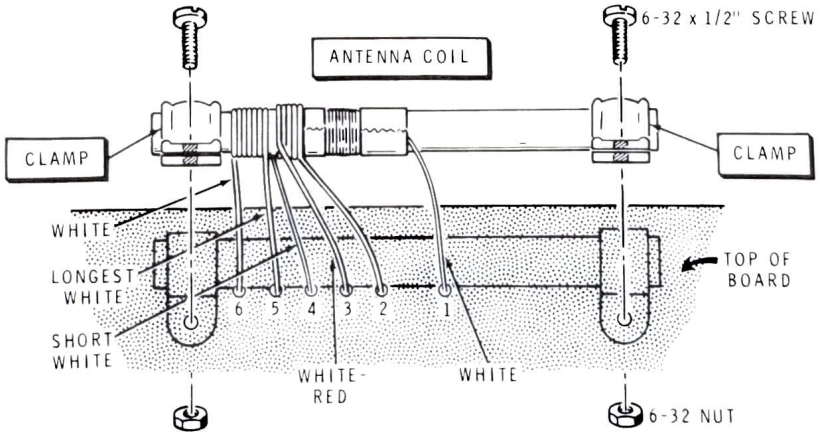


Detail 1-7

( ) Connect the white-red wire coming from hole 2 to screw A2. Do not install a nut.

( ) Connect a .001 μF capacitor from screw A3 to screw A2. Then install #3 lockwashers and nuts at A2 and A3. Tighten the screws and position the capacitor as shown.

The two remaining antenna leads will be connected later.

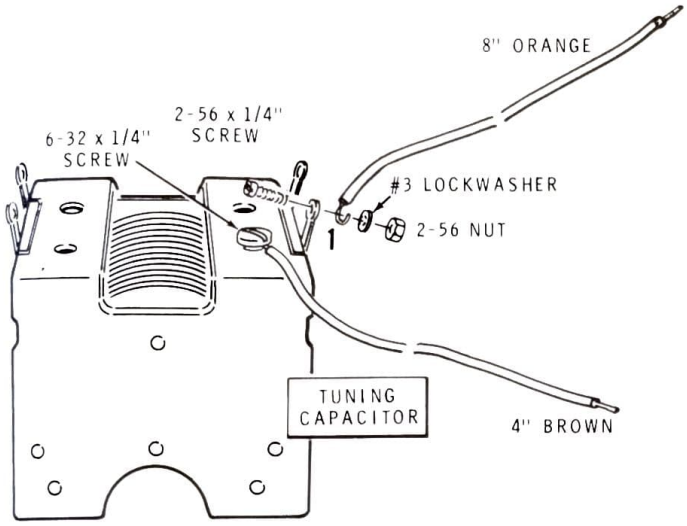


Detail 1-8

TUNING CAPACITOR

To protect the movable plates, keep the tuning capacitor in the fully closed position (see Detail 1-9) in the following steps.

( ) Set the tuning capacitor on your work surface as it appears in Detail 1-9, with the tuning shaft facing away from you.



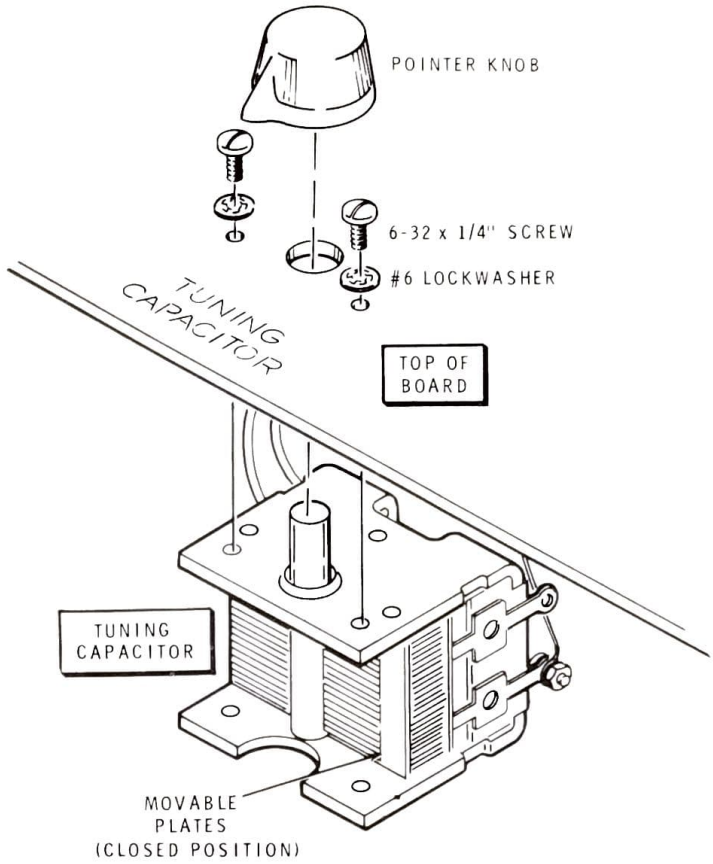
Detail 1-9

NOTE: Be sure to use a 6-32 x 1/4" screw in the next step.

( ) Connect one end of a 4" brown wire to the frame of the tuning capacitor, as shown in Detail 1-9, with a 6-32 x 1/4" screw.

( ) Connect one end of an 8" orange wire to lug 1 of the tuning capacitor. Use a 2-56 x 1/4" screw, a #3 lockwasher and a 2-56 nut. Tighten the screw.

( ) Refer to Detail 1-10 and mount the tuning capacitor to the workshop board in the hole marked "Tuning Capacitor." Use two 6-32 x 1/4" screws.

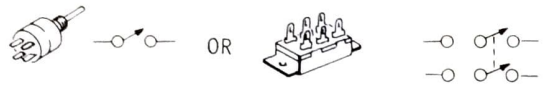


Detail 1-10

( ) Attach a pointer knob to the tuning capacitor shaft. Set the pointer at 550 (with the tuning capacitor plates closed) and tighten the set-screw.

( ) Connect the 4" brown wire coming from the tuning capacitor and the white wire coming from hole 4 to screw A4. Then install a #3 lockwasher and a 3-48 nut. Tighten the screw.

( ) Connect the 8" orange wire coming from the tuning capacitor and the white lead from hole 1 to screw A1. Then install a #3 lockwasher and a 3-48 nut. Tighten the screw.

SWITCH  OR

( ) Mount connector springs at locations S1 through S6.

( ) Refer to Detail 1-11 and mount the switch (either way) in the hole marked "Slide Switch." Use 6-32 x 1/4" screws.

( ) Refer to the inset drawing on Detail 1-12 and place the switch insulator on the switch.

( ) Connect 4" brown wires to the screws at S4, S5, and S6. Fasten the wires with 3-48 nuts and tighten the screws.

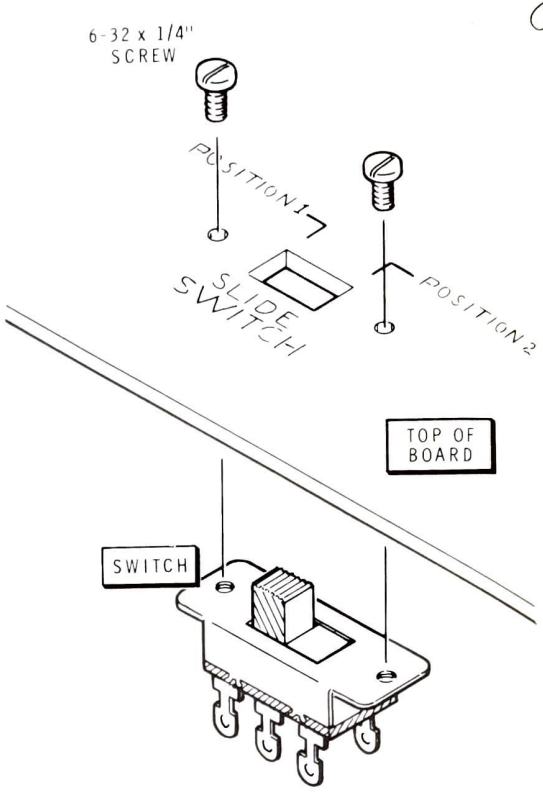
( ) Connect 4" brown wires to the screws at S1, S2, and S3. Fasten the wires with 3-48 nuts and tighten the screws.

NOTE: In the following steps, connect a wire to each switch lug as follows:

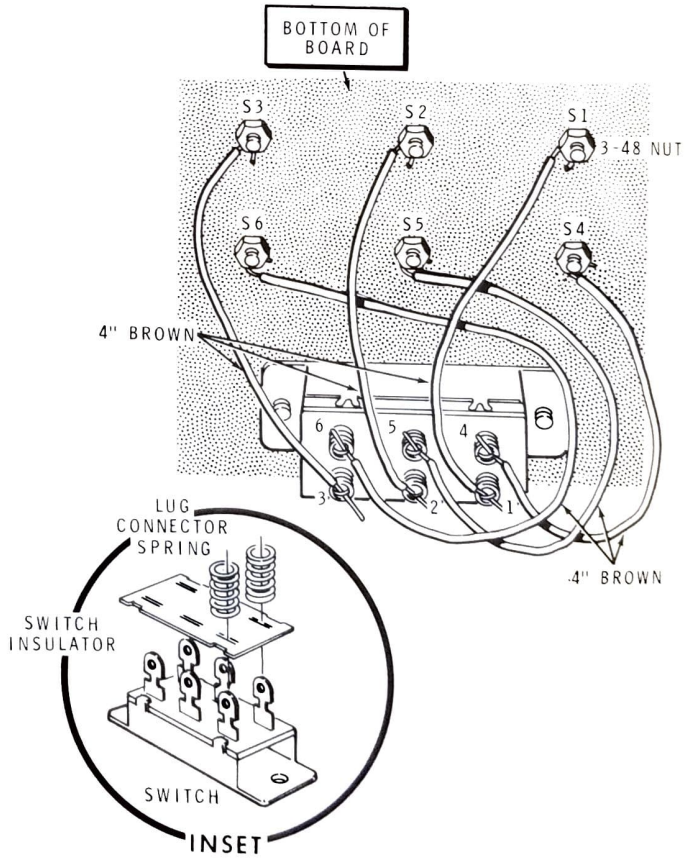
1. Put a lug connector spring on the lug.
2. Press down on the spring.
3. Route the wire to the lug as shown. Then insert it thru the hole until the insulation on the wire almost reaches the lug.
4. Release the spring.

Connect the wires as follows:

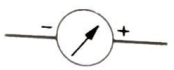
FROM	TO SWITCH LUG
( ) S4	4
( ) S5	5
( ) S6	6
( ) S1	1
( ) S2	2
( ) S3	3



Detail 1-11



Detail 1-12

METER  

( ) Refer to Detail 1-13 and attach the meter mounting bracket loosely to the back of the workshop board. Use 2-56 x 3/8" screws, #3 lockwashers, and 2-56 nuts. Then insert the meter and tighten the 2-56 nuts. Position the meter as shown.

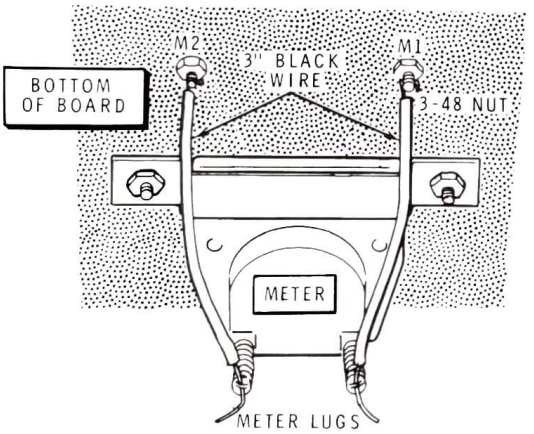
( ) Remove the thin wire connecting the meter lugs. Then bend the lugs up.

NOTE: To connect wires to the meter lugs, place two lug connector springs over each lug. See Detail 1-13.

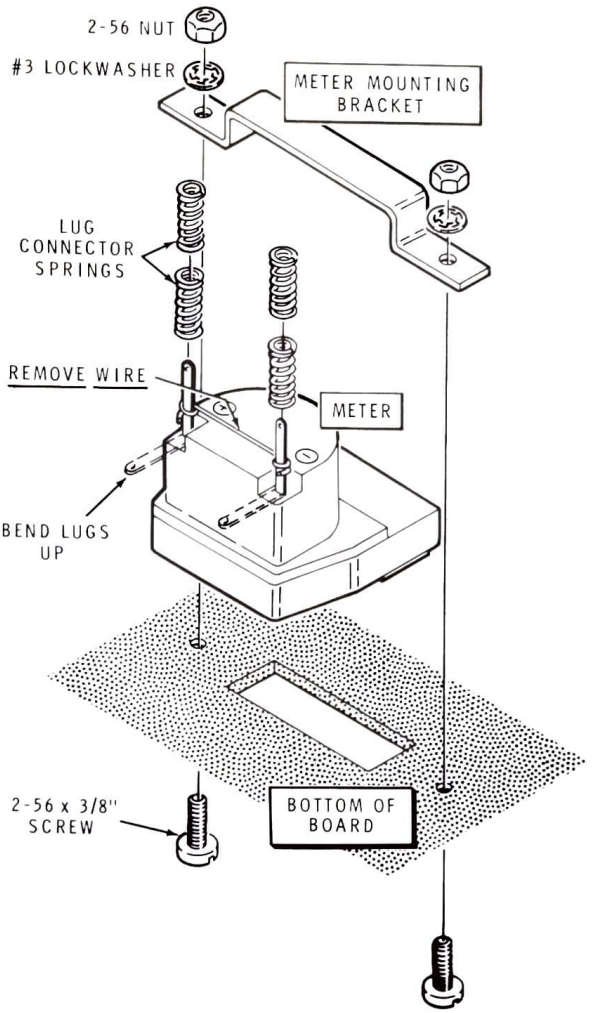
( ) Connect a 3" black wire to each of the meter lugs with lug connector springs. See Detail 1-14.

( ) Mount connector springs at M1 and M2 on the workshop board.

( ) Connect the meter wires to M1 and M2 as shown in Detail 1-14. Position these wires so their ends will not touch. Fasten the wires with 3-48 nuts and tighten the screws.



Detail 1-14



Detail 1-13

CONTROL

( ) Locate the control and bend the lugs as shown in Detail 1-15.

( ) Connect a 3" black wire to lug 1 and a 3" black wire to lug 3 of the control. Use 2-56 x 3/8" screws and 2-56 nuts.

( ) Refer to Detail 1-16 and mount the control with a control nut and control washer; do not tighten the control nut.

( ) Mount a connector spring on the workshop board at V2 with a 2-56 x 3/8" screw. Be sure the screw passes thru lug 2 of the control. Then tighten a 2-56 nut on the screw.

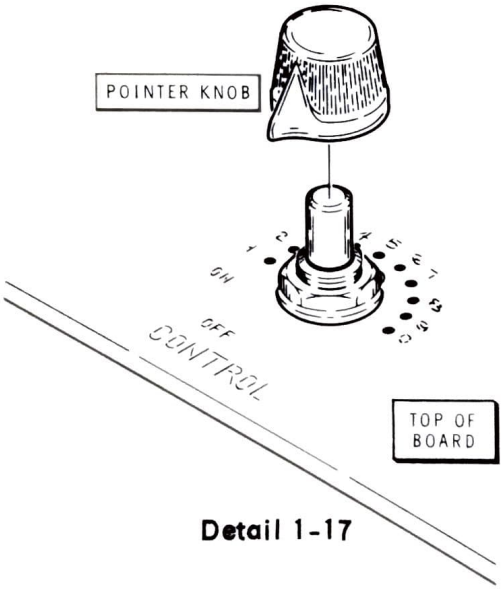
( ) Tighten the control nut.

( ) Mount connector springs at V1 and V3 with 3-48 x 3/8" screws.

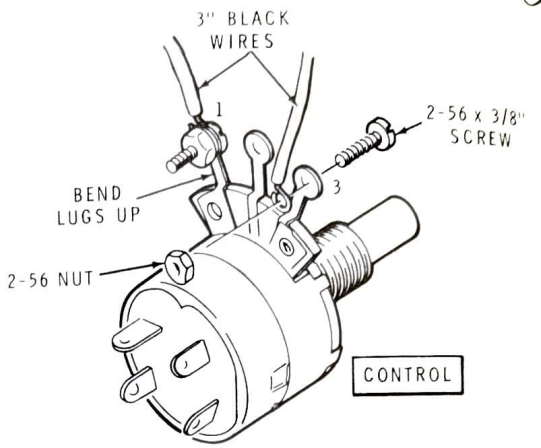
( ) Connect the wire from lug 1 of the control to screw V1. Then tighten a 3-48 nut on the screw.

( ) Connect the wire from lug 3 of the control to screw V3. Tighten a 3-48 nut on the screw.

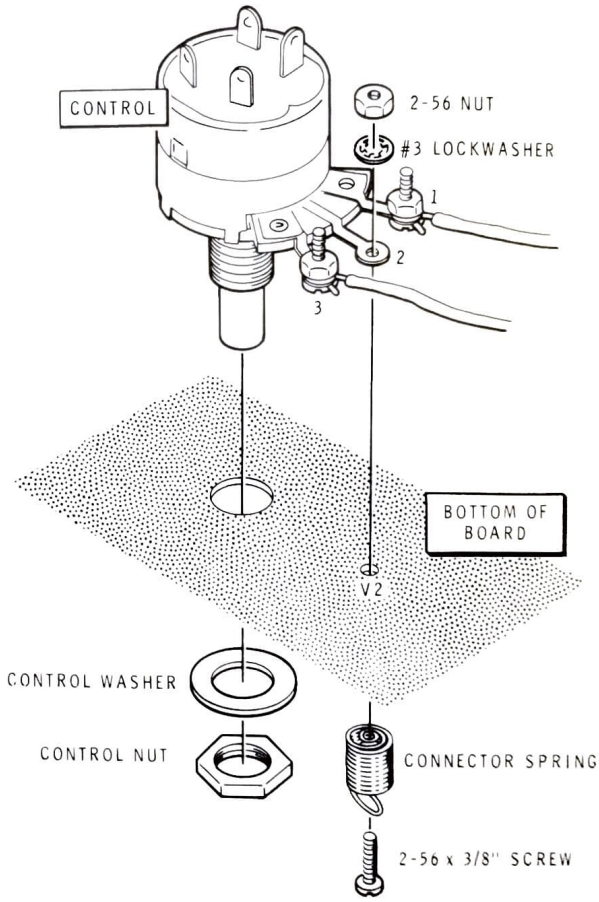
( ) Refer to Detail 1-17 and attach a pointer knob to the control shaft. Tighten the set-screw.



Detail 1-17



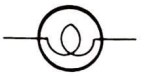
Detail 1-15



Detail 1-16

( ) Be sure the Control Switch is in the full counterclockwise position. If it is not, turn the pointer knob counterclockwise until you hear a click.

( ) Loosen the setscrew in this pointer knob. Then place the pointer at the OFF position and tighten the setscrew.

LAMP  

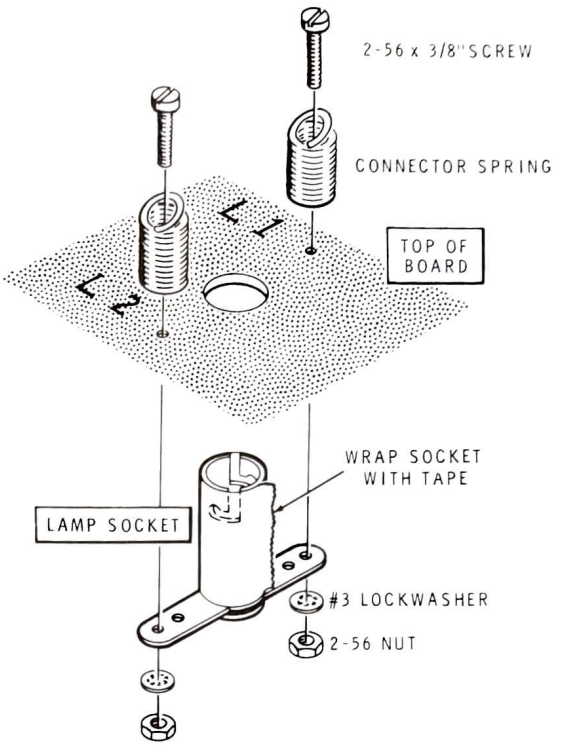
Refer to Detail 1-18 for the following steps.

( ) Wrap a 2" piece of tape (not supplied) around the lamp socket.

( ) Insert the lamp socket thru the workshop board (from underneath) between L1 and L2.

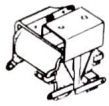
( ) Mount a connector spring at L1 with a 2-56 x 3/8" screw. Pass the screw thru the workshop board and thru the lug of the lamp socket. Fasten it loosely with a #3 lockwasher and a 2-56 nut.

( ) Mount a connector spring in the same manner at L2. Now tighten both screws and straighten the socket.



Detail 1-18

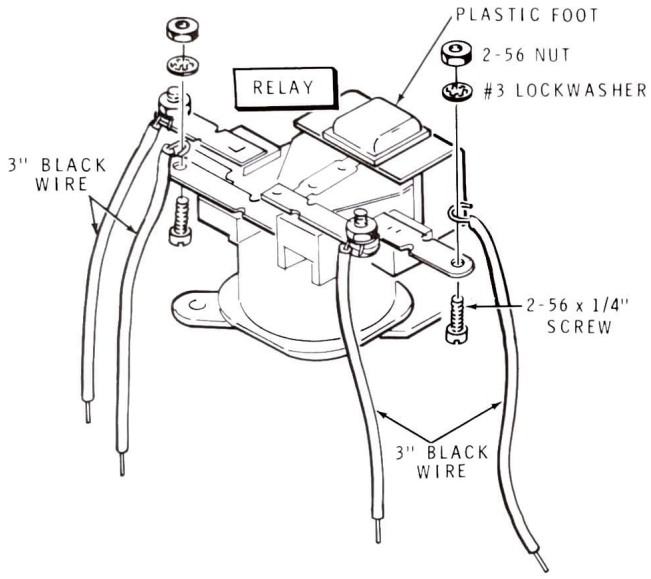
RELAY



NOTE: The plastic foot will be mounted on the relay in the next step. This will keep the relay from being damaged when you turn the Workshop over to work on the bottom of the board.

( ) Remove the paper backing from the plastic foot and install the foot on the relay as shown in Detail 1-19.

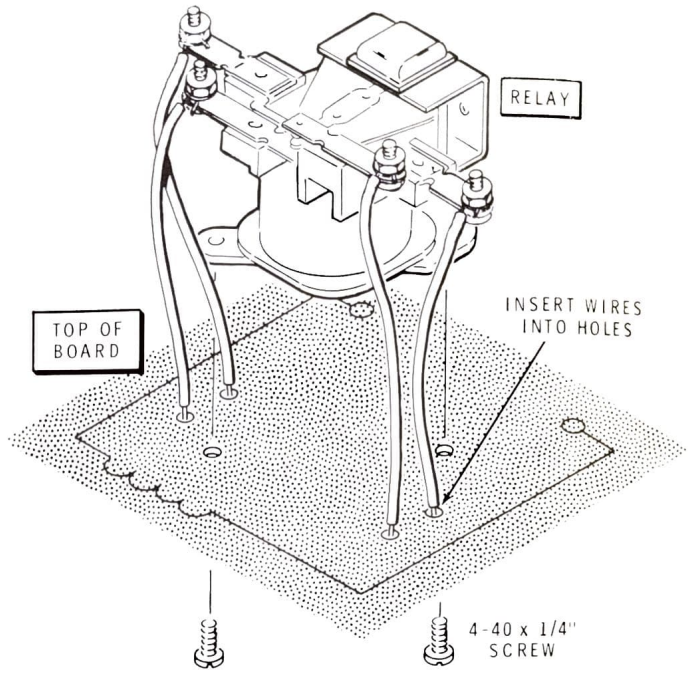
( ) Examine the relay and note the two bent-down lugs. Carefully bend these lugs out straight as they are shown in Detail 1-19.



Detail 1-19

NOTE: It may be necessary to thread the screws thru the relay terminals in the next step.

( ) Connect a 3" black wire to each of the four relay terminals. See Detail 1-19. Use 2-56 x 1/4" screws, #3 lockwashers, and 2-56 nuts. Position the wires as shown.



Detail 1-20

( ) Refer to Detail 1-20, insert these wires into the correct holes, and mount the relay on the board. Use the two 4-40 x 1/4" screws. Do not tighten screws.

( ) Connect a 3" black wire to the indicated relay mounting screw, as shown in Pictorial 1B. Then tighten both screws.

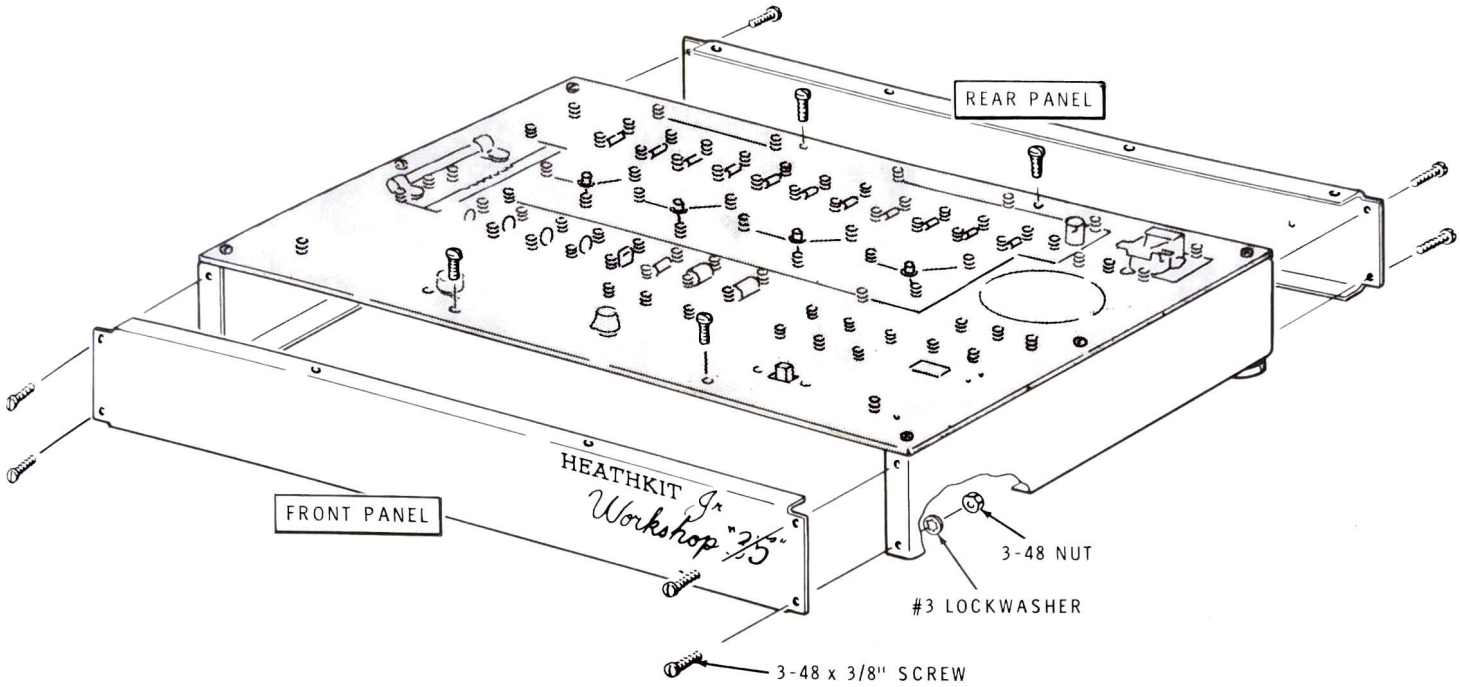
( ) Mount connector springs at RY1 thru RY5 (five springs) with 3-48 x 3/8" screws.

( ) Connect the five relay wires to the connector screws with 3-48 nuts as shown in Pictorial 1B.

WIRING

( ) Mount connector springs at N1, N2, N3, and N4 with 3-48 x 3/8" screws.

( ) Connect the length of bare wire from N1 to N2, N3, and N4. Wind the wire once around each screw.



Detail 1-21

( ) Connect an 8" orange wire to N4. Then install 3-48 nuts on N1, N2, N3, and N4. Tighten each of these screws.

( ) Insert a 3-48 x 3/8" screw at location "Y" (see Pictorial 1B).

( ) Connect a 4" brown wire to the screw at "Y". The other end will be connected later.

( ) Connect one lead of a .1 μF capacitor to the screw at "Y". Then install a 3-48 nut and tighten the screw.

( ) Mount connector springs at B1, B2, B3, and B4.

( ) Connect the other lead of the .1 μF capacitor to B4. Press the capacitor and leads flat against the workshop board as shown.

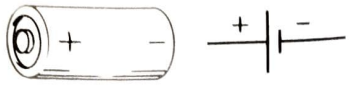
( ) Connect a 12" black and a 4" brown wire to B4 with a #3 lockwasher and 3-48 nut. The other ends will be connected later.

( ) Connect the other end of the 4" brown wire coming from B4 to B3 with a 3-48 nut. Then tighten the screw.

( ) Connect a 4" brown wire between B1 and B2. Install 3-48 nuts at B1 and B2 and tighten the screws.

( ) Refer to Detail 1-21 and mount the front and rear panels with 3-48 x 3/8" screws, #3 lockwashers, and 3-48 nuts. Install all twelve screws and nuts before tightening the screws.

POWER SUPPLY

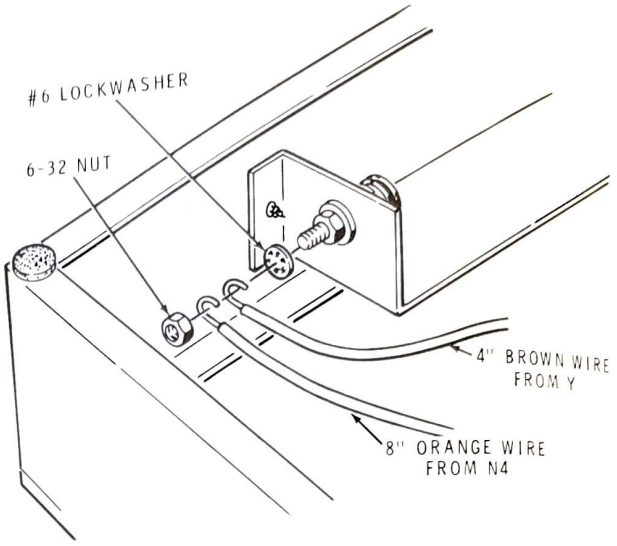


( ) Refer to Detail 1-22 and mount a battery bracket to the rear panel. Use four #6 sheet metal screws, and start all four screws before tightening.

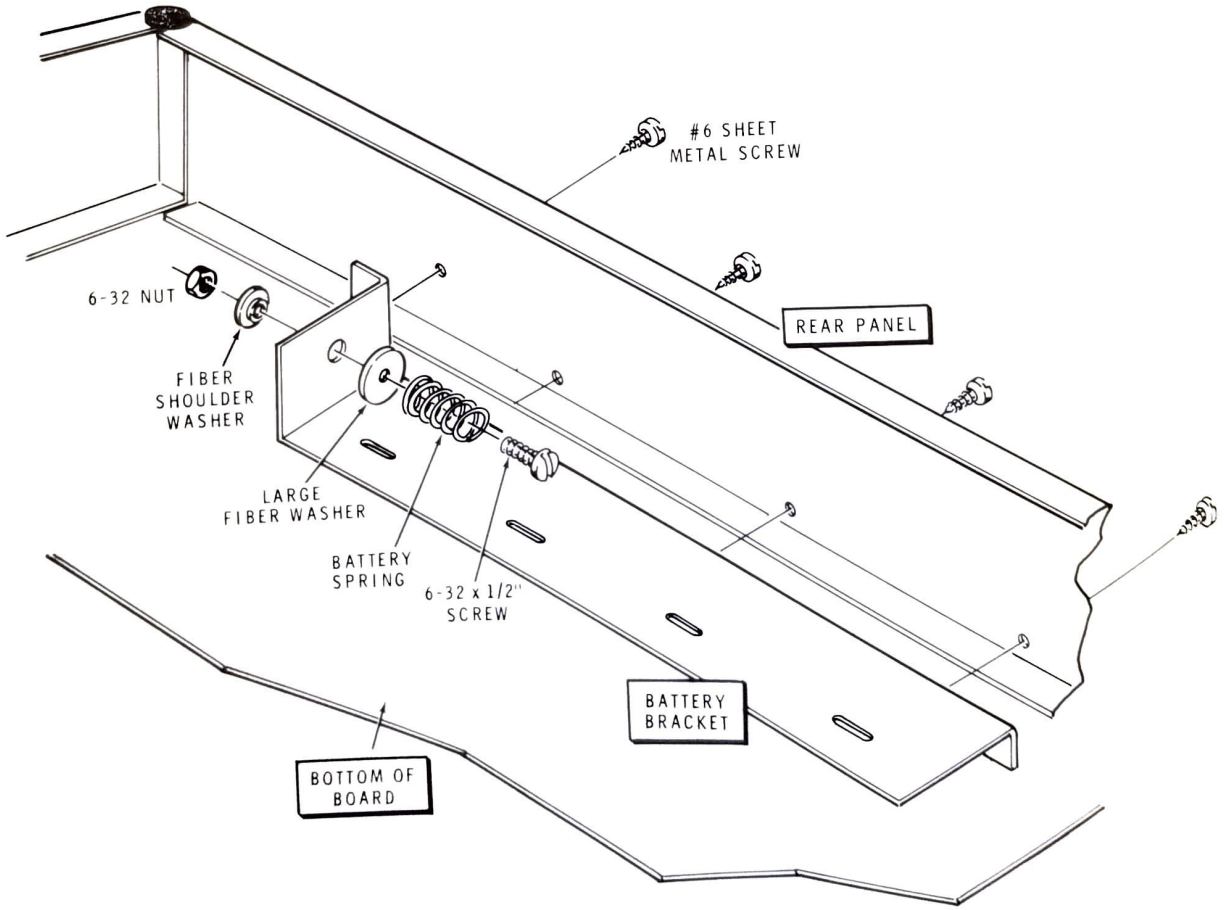
NOTE: Fiber shoulder washers are used in the following steps. These washers allow a screw to pass thru the metal bracket without touching it. Be sure the shoulder part of the washer is in the mounting hole.

( ) Assemble the battery spring and fiber washers to the end of the battery bracket as shown in Detail 1-22.

( ) Refer to Detail 1-23 and connect the 4" brown and 8" orange wires to the screw in the end of the battery bracket. Use a #6 lockwasher and a 6-32 nut.



Detail 1-23



Detail 1-22

( ) Refer to Detail 1-24 and assemble the fiber washers and a 12" black wire to the end of the other battery bracket.

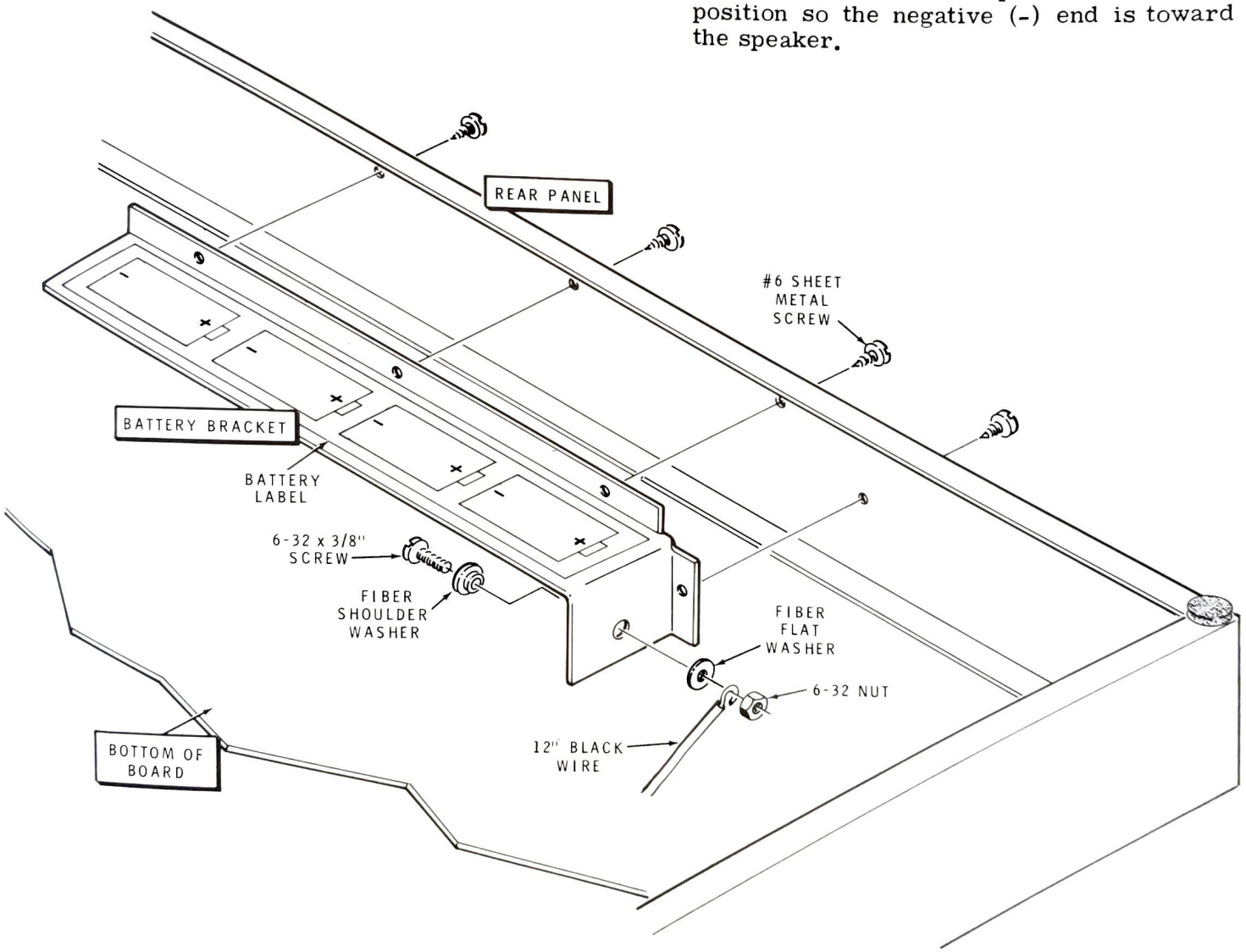
( ) Mount this battery bracket to the rear panel as shown with four #6 sheet metal screws. Start all four screws before tightening.

NOTE: In the next two steps, route the two 12" wires under the bare wire between N2 and N3 as shown.

( ) Connect the 12" black wire coming from the battery bracket to lug 4 on the control; use a lug connector spring as shown.

( ) Connect the 12" black wire coming from B4 to lug 5 on the control. Use a lug connector spring. Position the wires so the bare ends cannot touch.

( ) Carefully peel away the backing paper from the battery label. Then press the label in position so the negative (-) end is toward the speaker.



Detail 1-24

KEY

( ) Mount a connector spring and a jumper strip at K2 as shown in Detail 1-25.

( ) Attach a knob to the key as shown.

( ) Mount the key and a connector spring at K1 as shown. Align the key so it hits the jumper strip mounting screw when it is pressed.

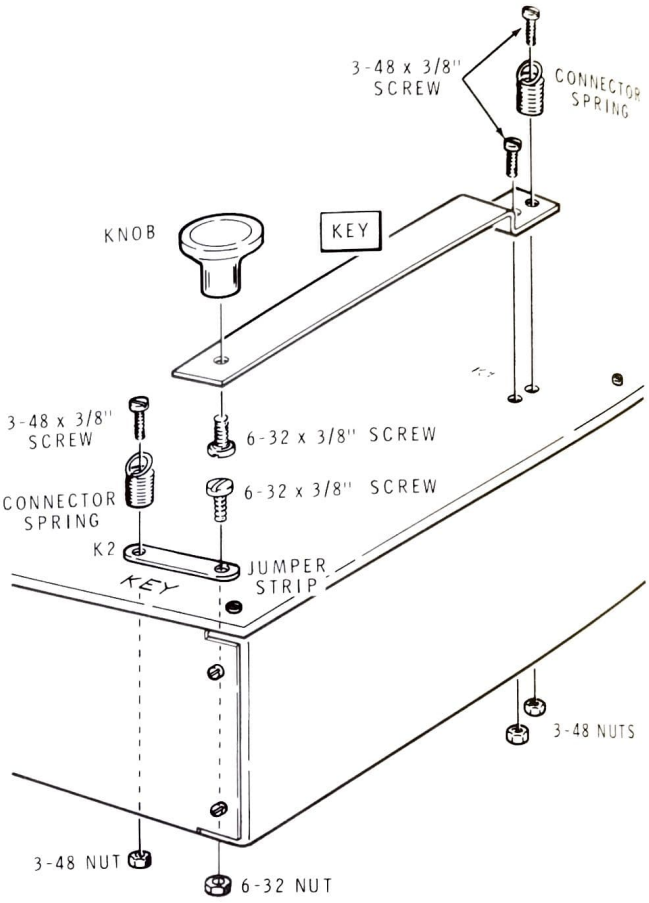
( ) Install the lamp in the lamp socket.

( ) Carefully peel away the backing paper from the blue and white identification label. Then press the label onto the base as shown in Pictorial 1B. Refer to the numbers on this label if you write to the Heath Company about this kit.

( ) Sign and date the label on the FCC Certification Form (597-472).

( ) Cut out this label and tape it onto the base as shown in Pictorial 1B.

This completes the assembly of the base of your Electronic Workshop. Carefully inspect all connections for loose wires. Gently twist each connector spring and tighten any that are loose. Be sure a nut is installed on each exposed screw and that all screws and nuts are tight. Make sure all wire and lead ends are placed so that they cannot touch any other connection.



Detail 1-25

REMOTE STATION

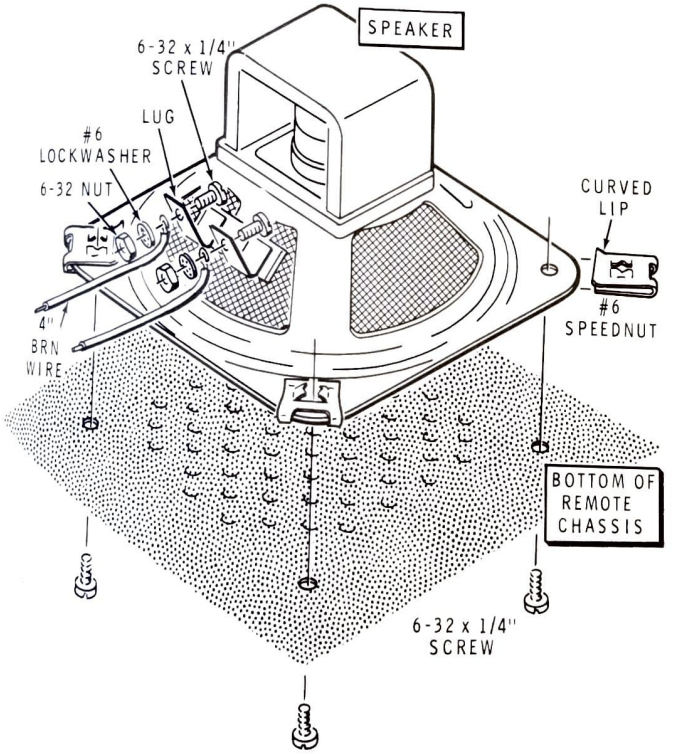
Refer to Pictorial 2 for the following steps.

( ) Remove the paper backing and press a felt foot into place on each end of the remote chassis bottom flange.

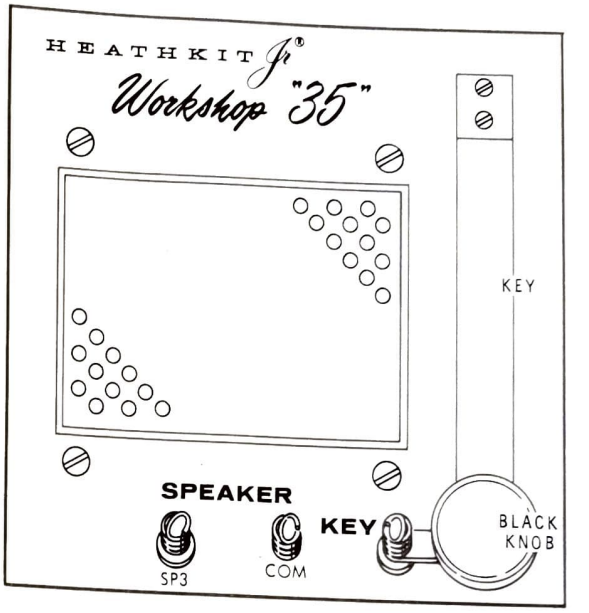
( ) Refer to Detail 2-1 and connect a 4" brown wire to each speaker lug as shown.

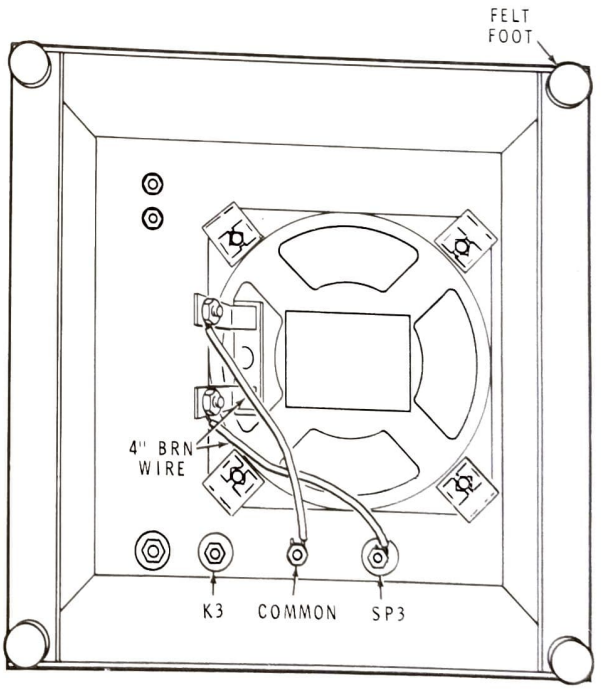
( ) Push a speednut on each corner hole of the speaker. The curved lip should be positioned as shown.

( ) Mount the speaker in the remote chassis with the lugs positioned as shown.

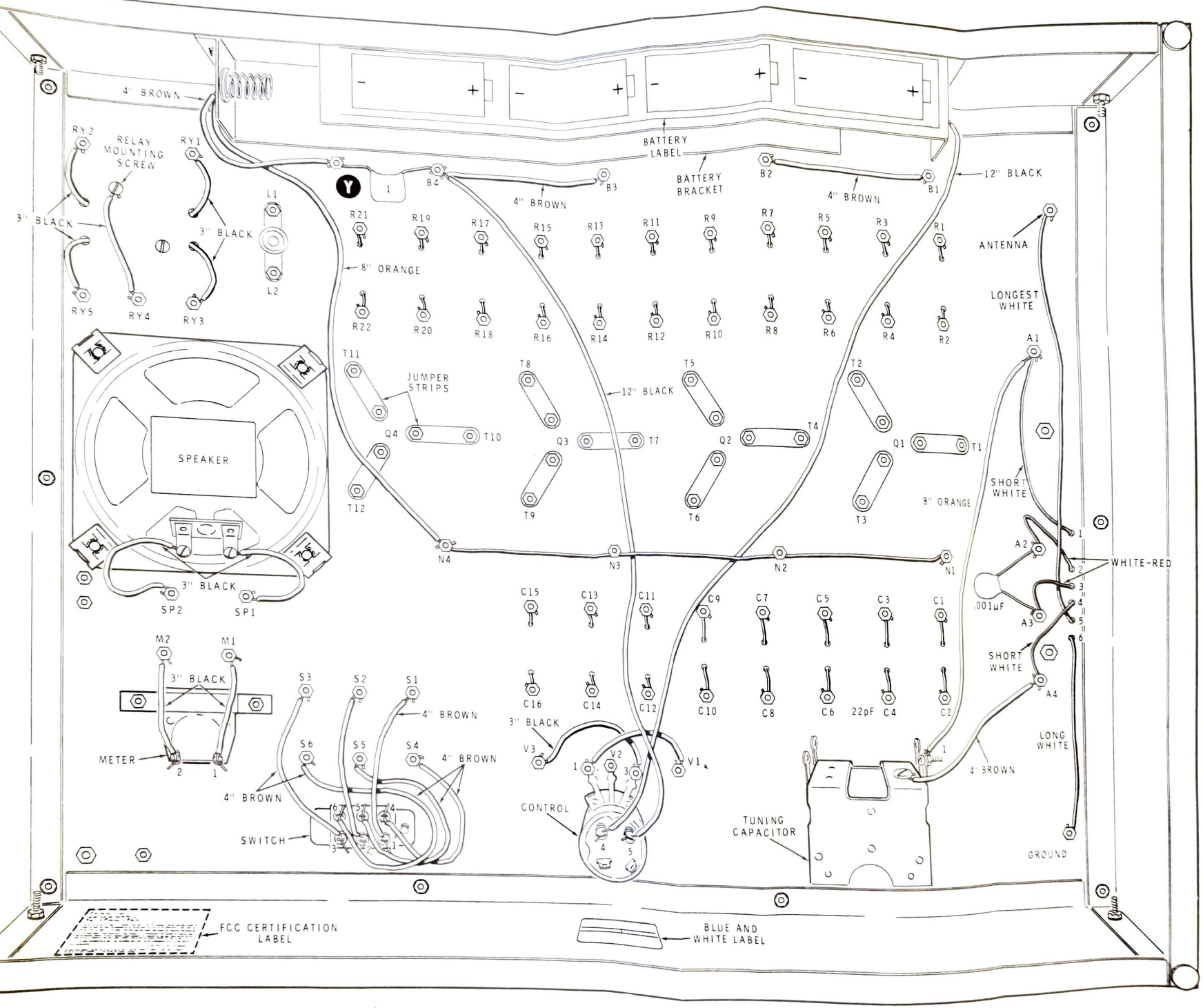


Detail 2-1





PICTORIAL 2



PICTORIAL 1B

( ) Refer to Detail 2-2 and assemble a connector spring and two fiber washers, with a speaker wire at SP3 as shown.

( ) In a similar manner, mount a jumper strip and connector spring at the corner of the Remote Station K3 as shown.

( ) Fasten the other end of this jumper strip to the remote chassis as shown.

( ) Assemble a connector spring and the remaining speaker wire at COM as shown.

( ) Attach a black knob to the key as shown.

( ) Mount the key on the remote chassis as shown. Align the key so it hits the jumper strip mounting screw when it is pressed.

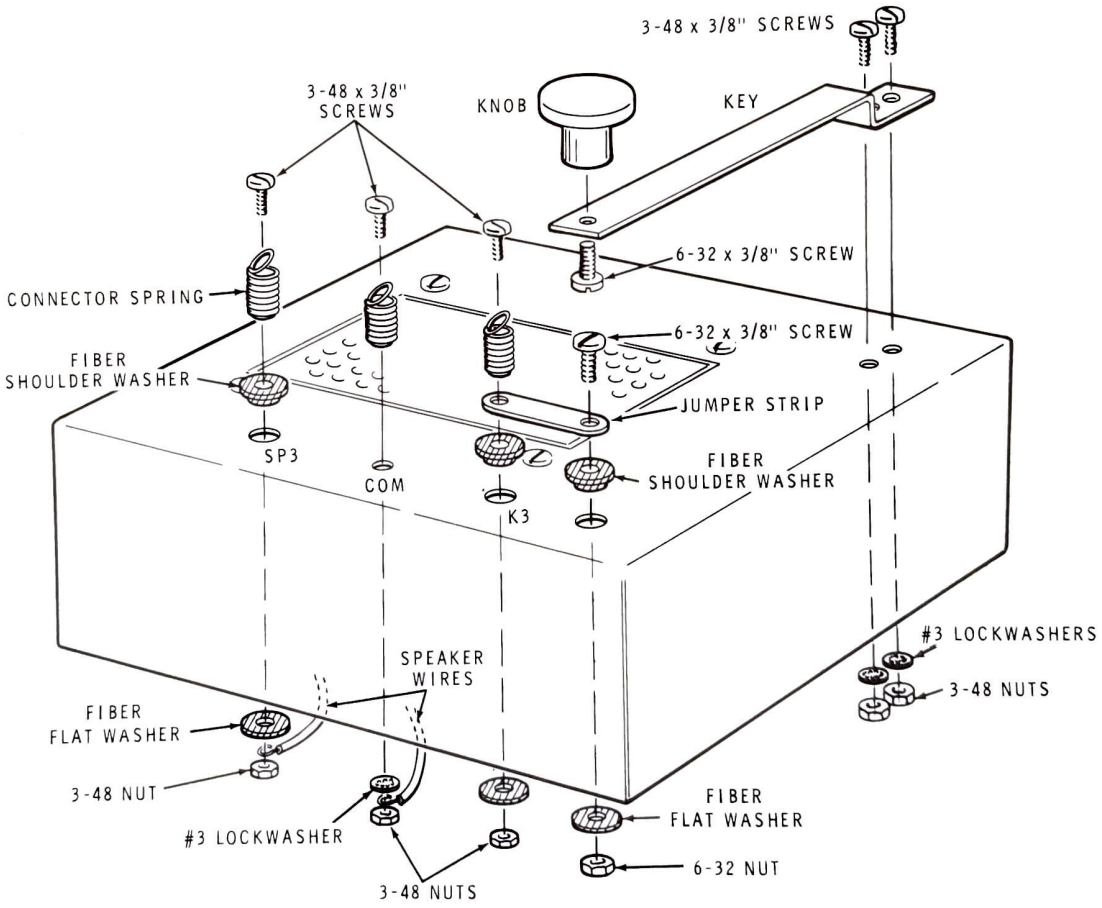
( ) Remove about 1/2" of insulation from each end of the 25 foot white and 25 foot white-blue wires.

These two wires will be used in the Experiments. You may want to roll them up and place a rubber band around them until they are called for later.

BATTERY INSTALLATION

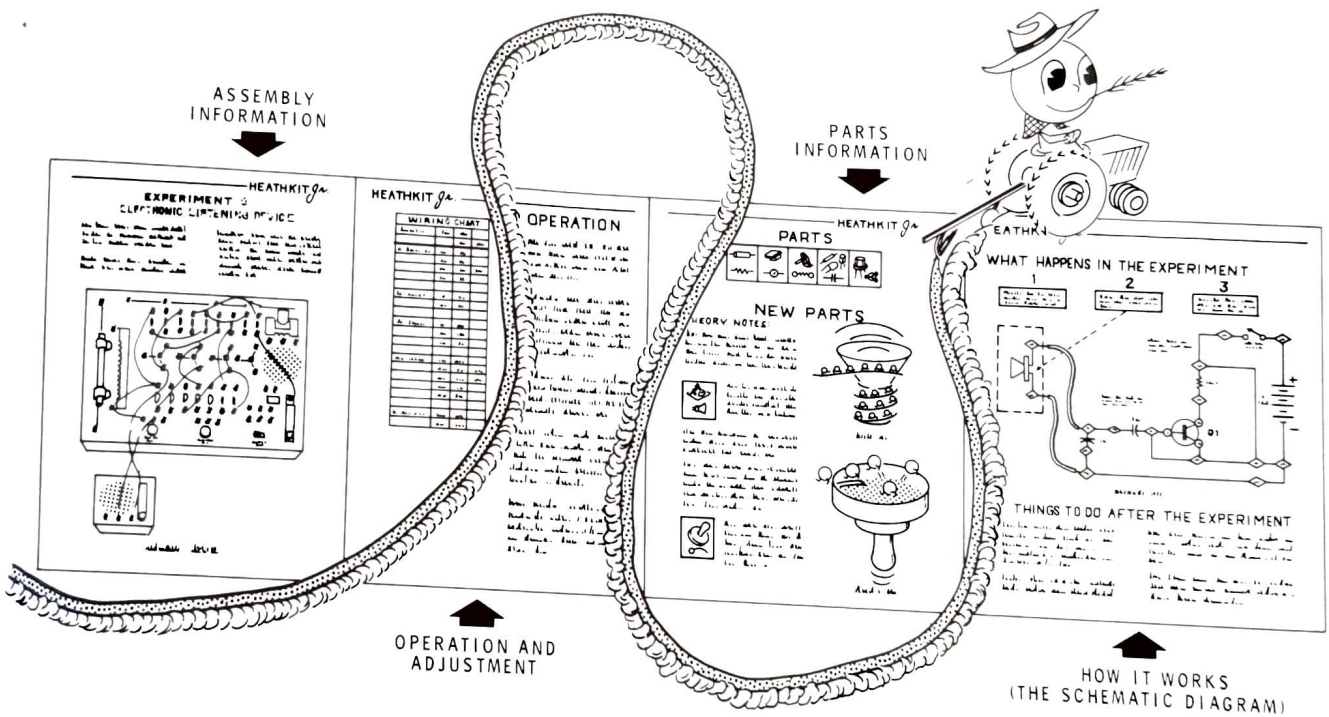
( ) Turn the Control on the Workshop to the OFF position and insert the batteries in the battery bracket. Be sure to position them as the label shows.

The Workshop "35" Assembly section is now complete. Be sure to read the next section, "How To Do Experiments," before you start the Experiments themselves.



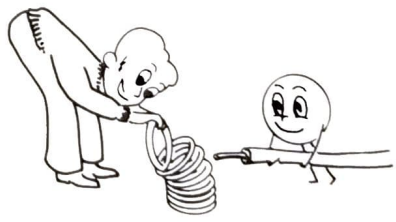
Detail 2-2

HOW TO DO EXPERIMENTS



A TYPICAL EXPERIMENT

Before you start an Experiment, read the short paragraph just after the title; this tells you what it is all about. Then, to put the Experiment together, just install the wires as they are listed in the Wiring Chart and shown in the Pictorial. (To connect a wire, just slip the end of it in between the turns of a spring.)



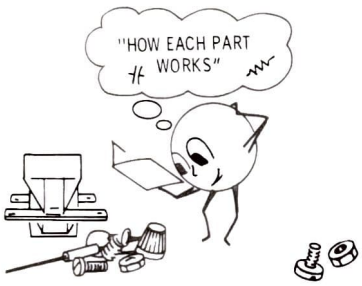
When all the wires are installed, the Operation section will tell you about any adjustments you must make. It will also tell you how to use the device you have just built. If the Experiment does not operate as it should, refer to "In Case Of Difficulty" on Page 153.

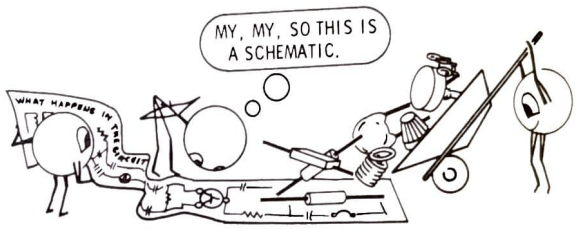
After you have completed an Experiment, remove the wires from the springs and set them aside where you can easily get them for the other Experiments.

NOTE: Any group of electronic parts that are connected together to do something useful is called a *circuit*. For example, you will build a Code Flasher *circuit* in Experiment 1, and a Rain Alarm *circuit* in Experiment 6.

HOW TO UNDERSTAND THE EXPERIMENTS

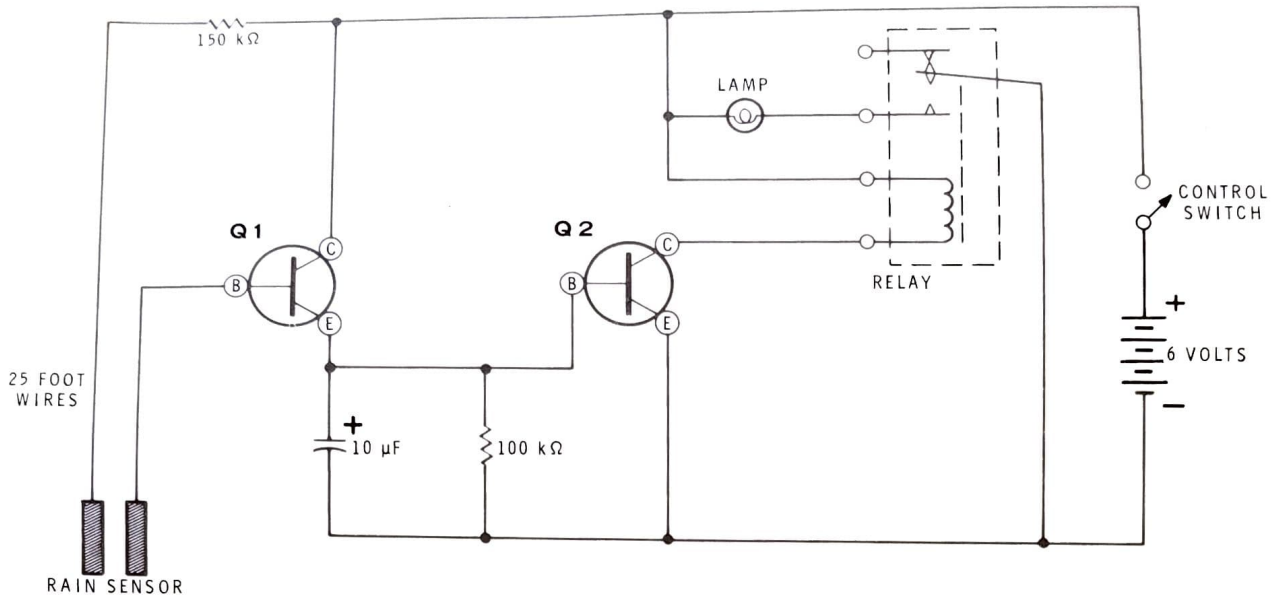
Read the "Parts" and "What Happens In The Circuit" sections to see how the Experiments work. The Parts section will explain how each part works (in the Experiment where it is first used), and will show the symbol for each part. The symbol for a resistor, for example, looks like this:-∿∿-.





To understand the Experiments best, perform them as they occur (1, 2, 3, etc.) in the Manual. Then you will not use any part until after you learn how it works. This will also make it easier for you to build and understand the larger, more complicated Experiments that occur later.

In each Experiment, the "What Happens In The Circuit" section uses the parts symbols in a *schematic* diagram. This *schematic* shows how the parts are connected together; and a few small paragraphs are on it to tell you how the circuit works. Be sure you know how each part works (see the parts descriptions) before trying to understand the *schematic*.



The illustration above is included to show you the kind of schematic that an engineer would use. This is the same as the Schematic for Experiment 6 on the fold-out from Page 55. Note that diamond-shaped symbols are added to it on this fold-out. These symbols are on all of the schematics in this Electronic Workshop to show you where the spring connectors are at.

EXPERIMENTS

Use the following list if, during an Experiment, you want to reread the explanation for one of the parts. The Dictionary (Pages 159 to 161) has additional information about most of these parts.

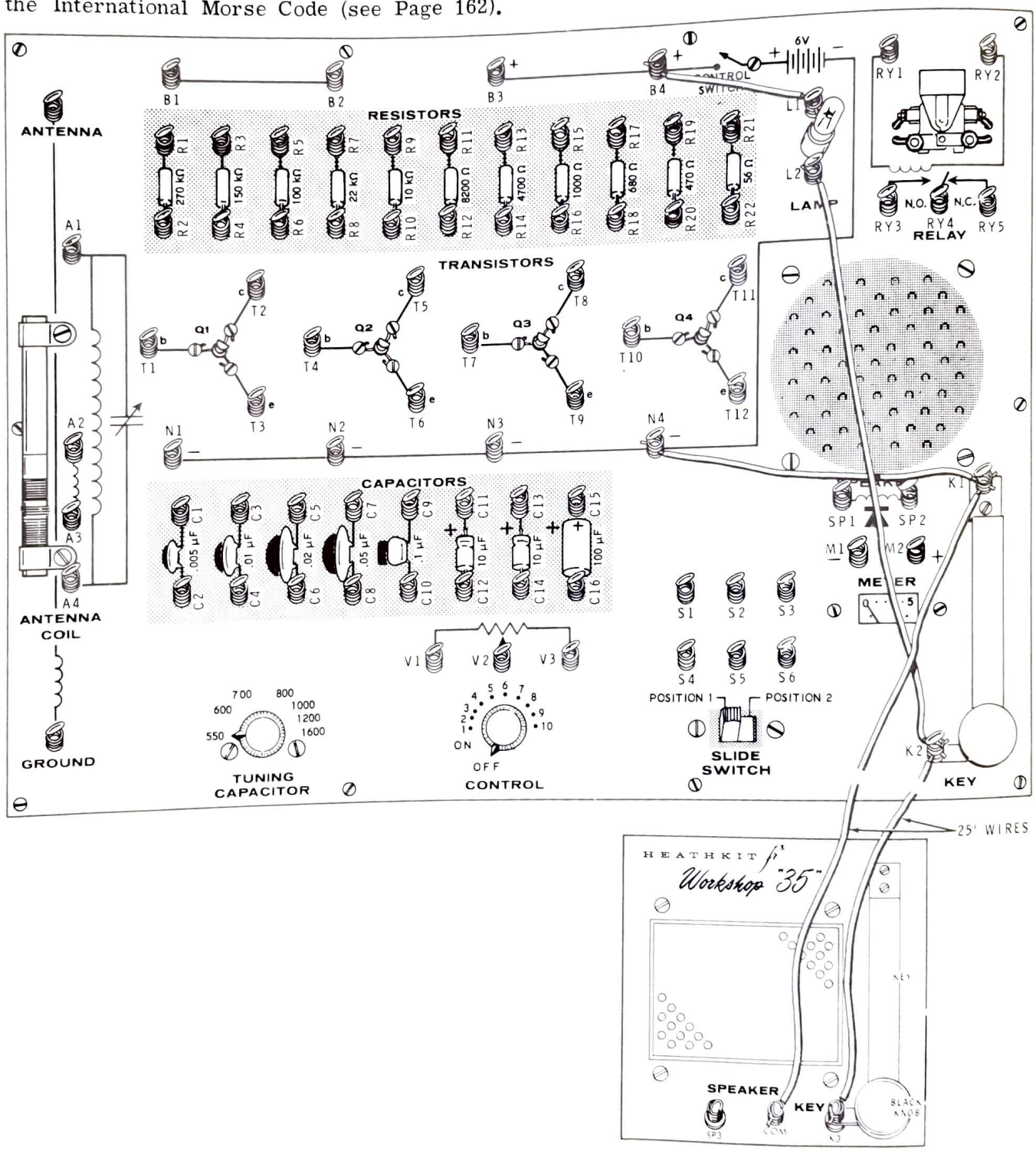
Refer to the following Pages for a brief theory explanation on each of the following subjects.

EXPERIMENT 1

Code Flasher

The Code Flasher circuit you build in this Experiment will flash a signal when you press the Key. Use this circuit to send messages and learn the International Morse Code (see Page 162).

You will also hook up the Remote Station with long wires so you can send signals from two locations.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
ONE 3" BLACK	B4	L1	
ONE 6" RED	N4	K1	
ONE 10" YELLOW	K2	L2	
25' WHITE	K1	COM *	
25' WHITE-BLUE	K2	K3 *	

* NOTE: THE COM AND K3 TERMINALS ARE ON THE REMOTE STATION.

OPERATION

TESTING THE FLASHER

( ) Turn the CONTROL clockwise until it clicks ON.

( ) Press the KEY on the Workshop; the Lamp should light. The Lamp should also light when you press the KEY on the Remote Station. If the Lamp does not light, refer to the "In Case Of Difficulty" section (Page 153).

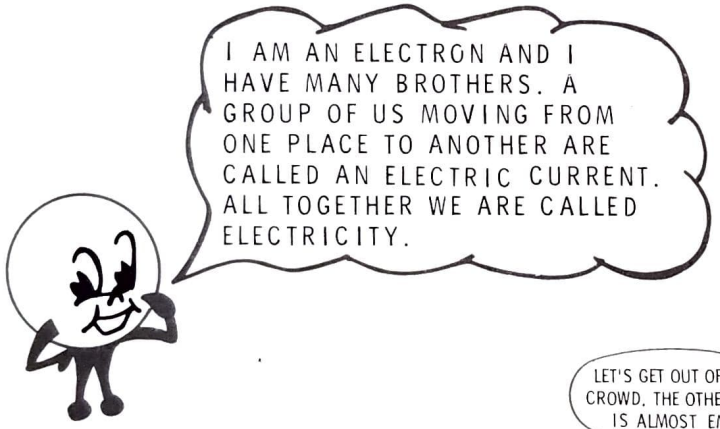
USING THE CODE FLASHER

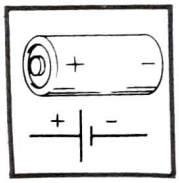
Look at the International Morse Code on Page 162. See how each letter and number is represented in code by a certain combination of dots and dashes. "E", for example, has only one dot. "T" has only one dash.

Hold the KEY down briefly to send a dot, and longer to send a dash. You will find, when you learn the code, that you can send signals and receive them quite rapidly. You might want to begin practicing by sending your name in code.

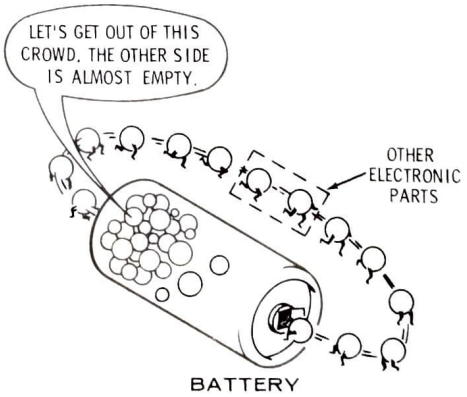
( ) Turn off the CONTROL when you are thru using the Code Flasher.

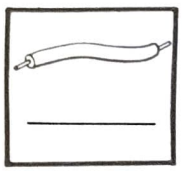
PARTS



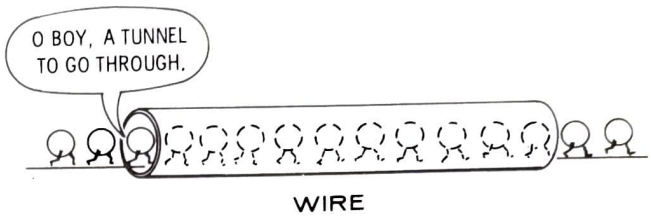


BATTERY - A battery makes electricity by pushing electrons out one end and letting them flow in the other end. When a battery is wired to other electronic parts, it pushes an electric current thru these parts.

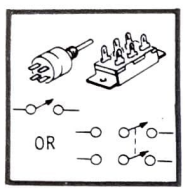




WIRE - Wires form a path the electric current can flow thru, like a long line of people going thru a crowded tunnel.

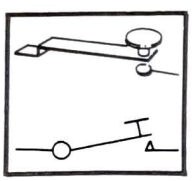


WIRE

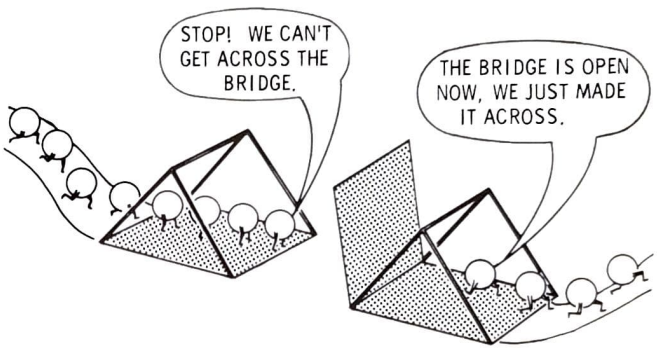


SWITCH - A switch opens and closes like a drawbridge. It lets current flow thru the wires and parts from one side of the battery to the other.

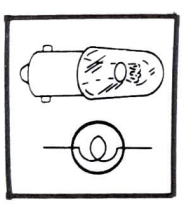
There are two switches in your Workshop: the Slide Switch and the Control Switch. The Control Switch is attached to the back of the Control.



The KEY also acts like a switch. When it is pressed down, it lets the current flow.

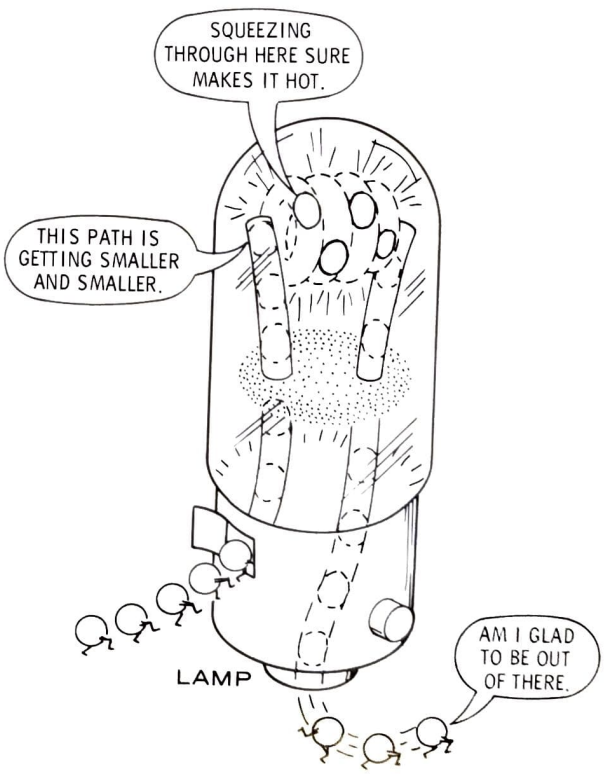


SWITCH



LAMP - Electric current flows into one terminal, thru the filament, and out the other terminal of the lamp. The current makes the filament get white hot. The white hot filament gives off light, just like a small fire would.

NOTE: A more complete description for most of these parts can be found in the Dictionary on Page 159.



LAMP

WHAT HAPPENS IN THE CIRCUIT

2

The CONTROL SWITCH must be turned on so the Code Flasher can operate. Then current can pass thru it when the Key is pressed.

1

The BATTERIES supply electricity to the rest of the circuit.

3

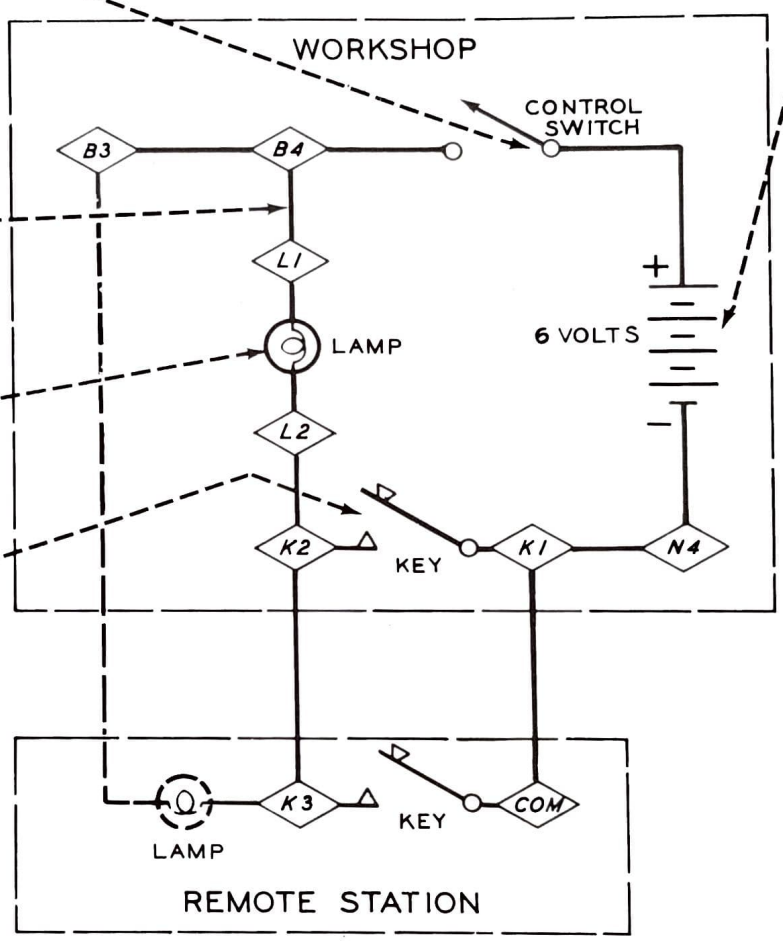
The WIRE makes a path for the current to get from one part to another.

4

The LAMP glows when an electric current goes thru it.

5

When the KEY is pressed, current flows thru it to the other parts.



THINGS TO DO AFTER THE EXPERIMENT

You may wish to add another lamp to this circuit at the Remote Station. This will allow you to signal back and forth with a friend in another room. You may purchase additional wire, another #47 lamp, and a lamp socket from your local radio TV store. Leave your Workshop wired and attach the new parts as follows:

( ) Attach a long piece of wire to one terminal of the new lamp socket.

( ) Attach a short wire to the other terminal of the new lamp socket.

( ) Install the #47 lamp in the new lamp socket.

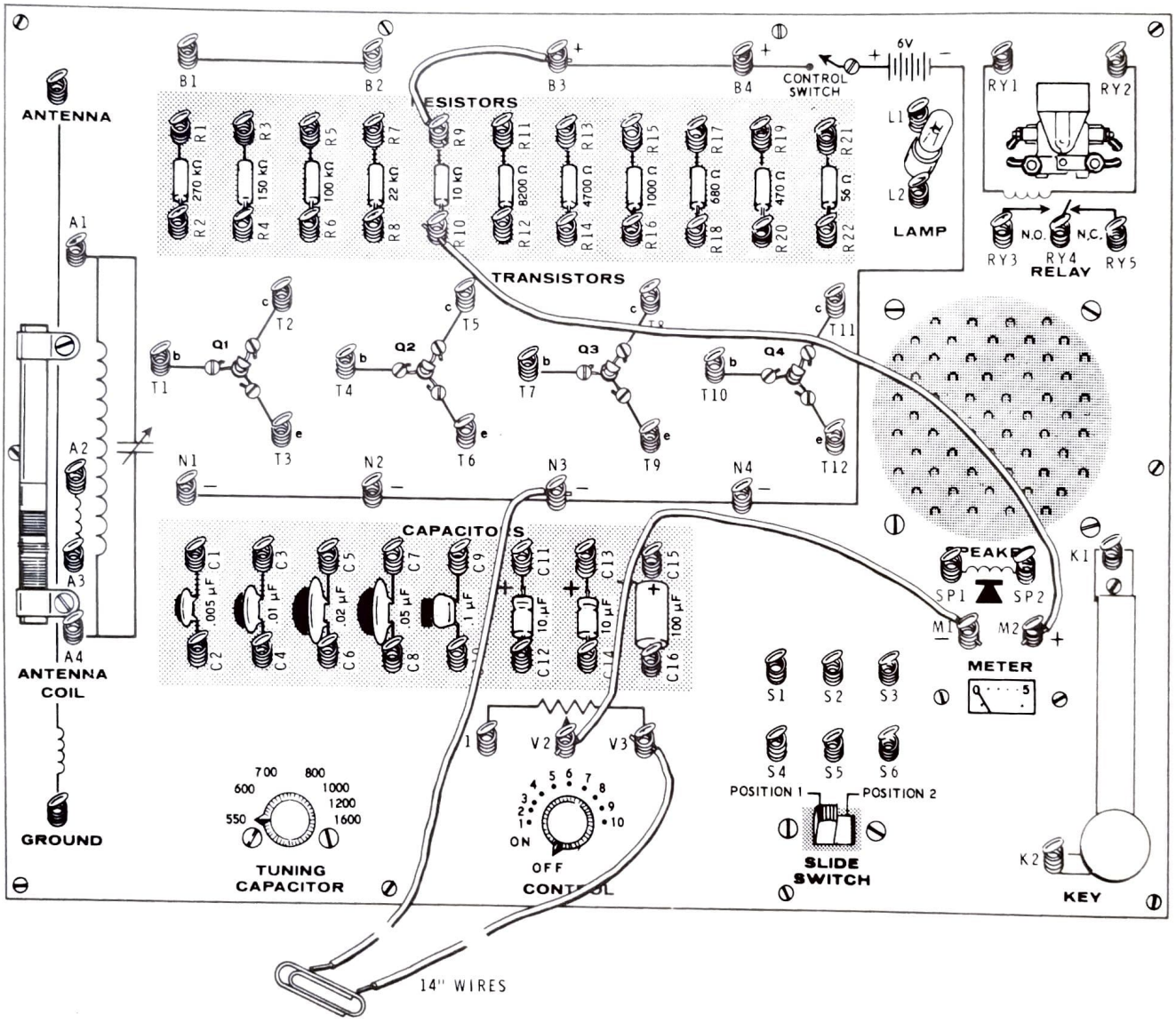
( ) Attach the long wire to B3 on the Workshop base.

( ) Attach the short wire to K3 on the Remote Station.

Both lamps will now flash when either Key is pushed.

EXPERIMENT 2
Continuity Tester (Ohmmeter)

This Tester may be used to see if various materials (such as wood, paper, metal, etc.) will conduct electricity. Two 14" wires will connect your Workshop to the items being tested. These test wires will be called TEST PROBES.



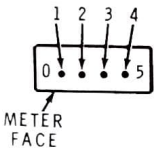
WIRING CHART			
USE	FROM	TO	
		FROM	TO
ONE 3" BLACK	R9	B3	
ONE 8" ORANGE	V2	M1	
ONE 12" BLACK	M2	R10	
TEST PROBES			
TWO 14" BROWN	V3		
	N3		

OPERATION

CONTINUITY TESTER CALIBRATION

( ) Turn the CONTROL to position 1.

NOTE: The dots on the Meter stand for numbers 1, 2, 3, and 4. See the accompanying illustration.



( ) Touch together the ends of Test Probes V3 and N3. The Meter should read between 2 and 3.

( ) With the Test Probes touching each other, turn the CONTROL clockwise until the Meter reads at 5. (Remember: clockwise is the way the hands on a clock turn.)

NOTE: If the Meter fails to read, refer to "In Case Of Difficulty" on Page 153.

APPLICATIONS

WARNING Do not test anything that is plugged into a wall outlet, like a lamp or toaster. You could seriously hurt yourself and your Electronic Workshop. Batteries should not be tested either, as this could damage the Meter.

NOTE: Some of the following things will conduct electricity and make the Meter read, and others will not. With good conductors, the Meter needle will point to 5. With poor conductors it will point to 2 or 3. If the needle stays at zero, the material is an ***insulator***, a material that will not conduct electricity at all.

Test each of the following items by touching both Test Probes to it at the same time: a coin, paper clip, black pencil lead, colored pencil lead, crayons, dry paper, wood, wet paper and glass.

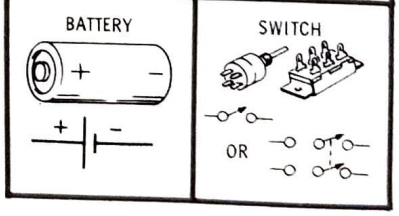
NOTE: It is quite harmless for you to touch the wires in your Workshop because they are all at low voltage levels (6 volts or less). But never touch wires in other electric circuits or you could receive a bad electric shock.

Hold the Test Probes between your fingers to see how much electricity your body will conduct. Then wet your fingers and see the difference. Water helps other objects conduct electricity.

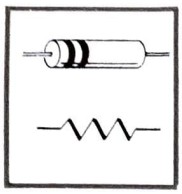
Turn off the CONTROL when you are thru using the Continuity Tester.

PARTS

OLD PARTS



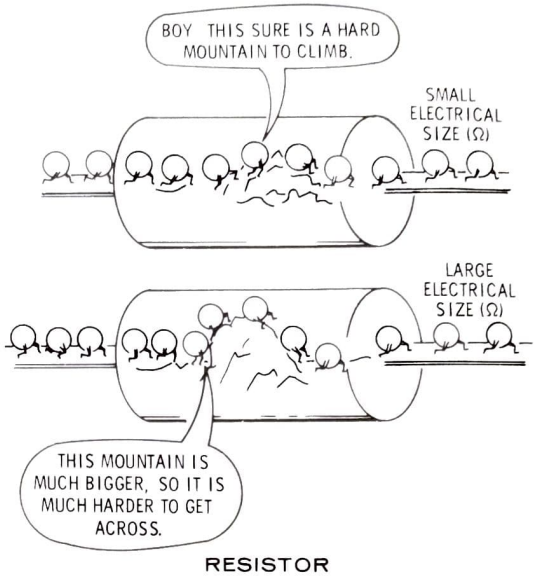
NEW PARTS



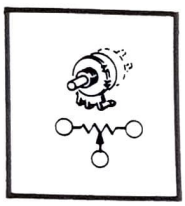
RESISTOR - The important thing about a resistor is its electrical size. Its electrical size is stated in "ohms (Ω)." For example: 22 Ω, or 47 Ω.

If a resistor is small (in electrical size), current flows thru it easily. But it is much harder for current to pass thru a large resistor. Resistors allow only a certain amount of current to flow in a circuit.

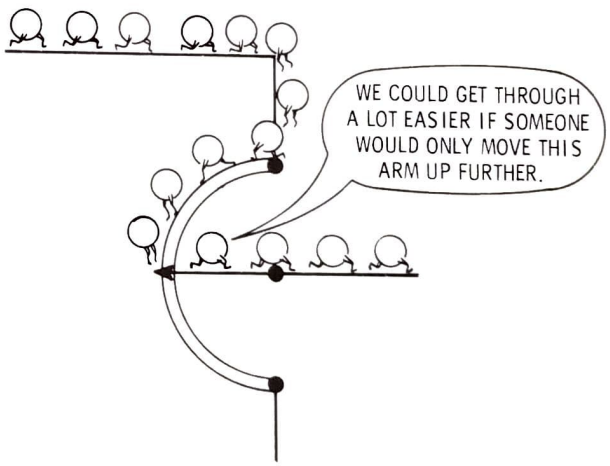
kΩ = Ω x 1000. For example, 22 kΩ = 22 Ω x 1000 = 22,000 Ω.



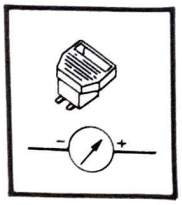
RESISTOR



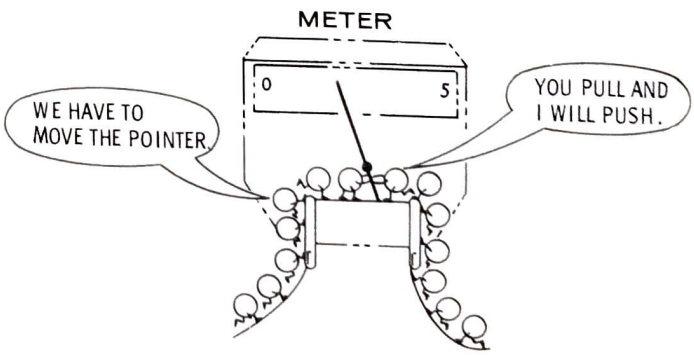
CONTROL - A control is a resistor whose electrical size can be changed. When you turn the shaft one way, its resistance gets larger. When you turn the shaft the other way, its resistance gets smaller.



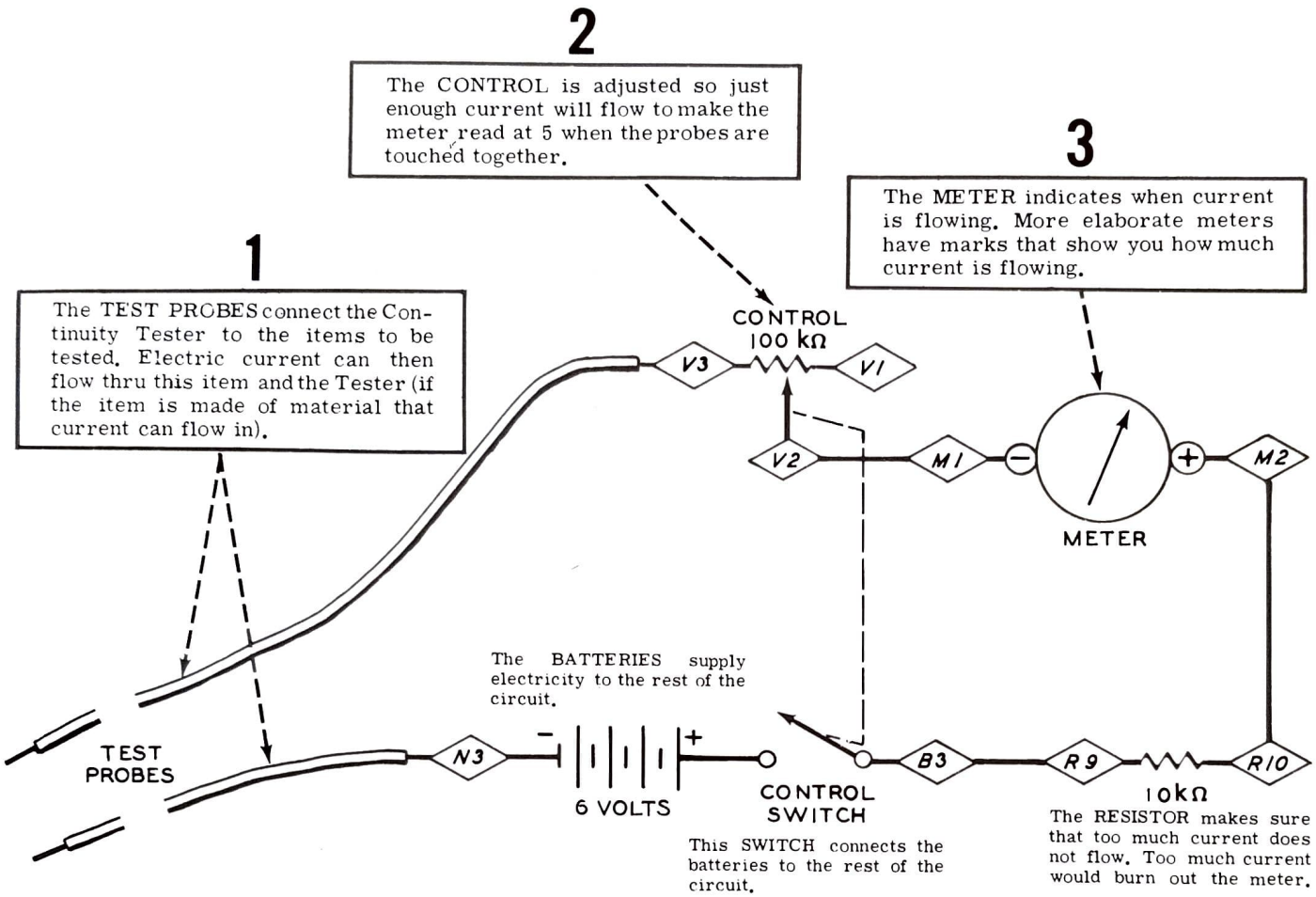
CONTROL



METER - A meter measures the amount of electric current that flows thru it.



WHAT HAPPENS IN THE CIRCUIT



THINGS TO DO AFTER THE EXPERIMENT

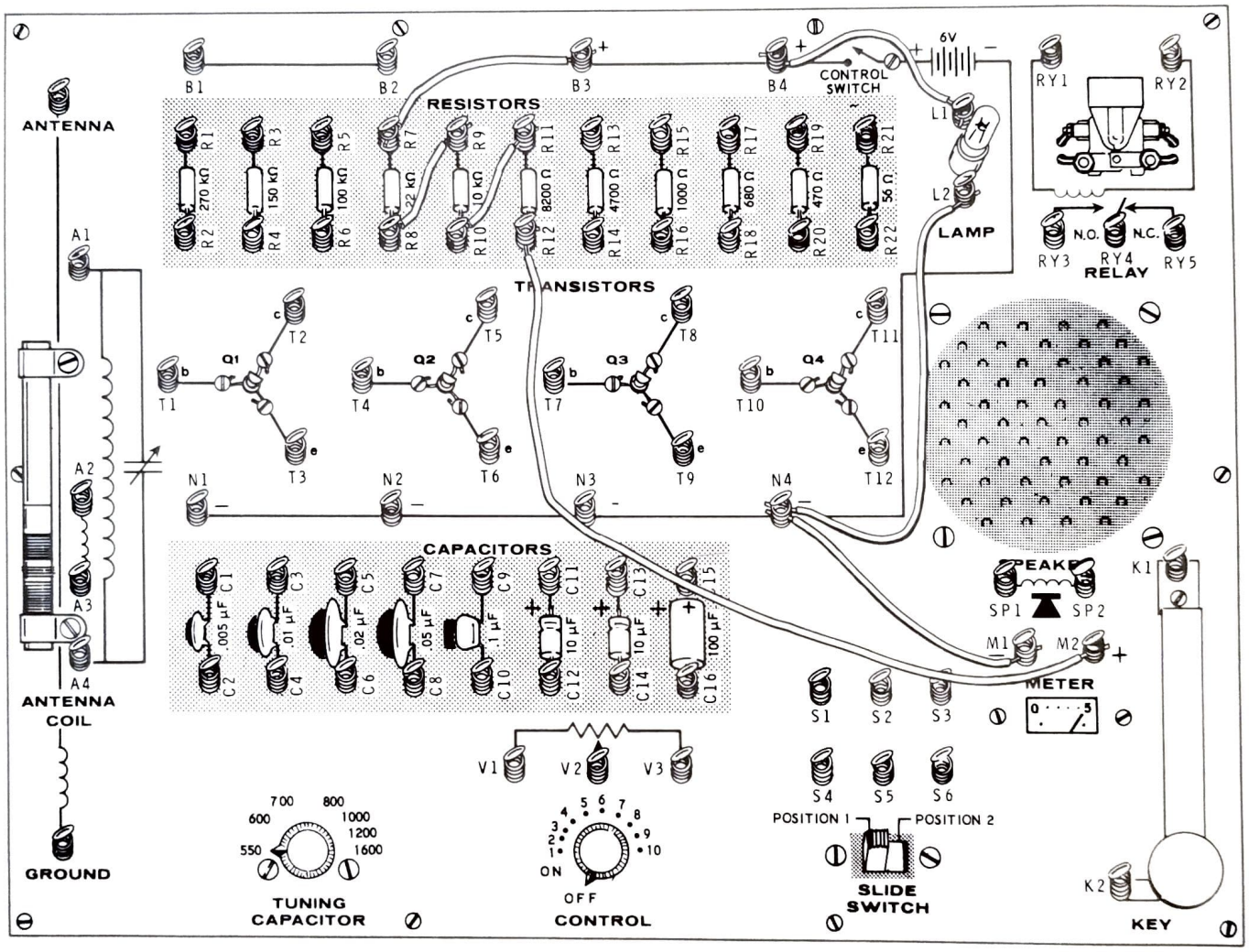
Ask your family or friends for other things you might try. Test the items by touching both Test Probes to them. Some items you could try are: nails, screws, pots without Teflon*, pots with Teflon, aluminum foil, and boxes.

*DuPont Registered Trademark

EXPERIMENT 3

Battery Tester

In this Experiment you will build two different testers. The 6 Volt Tester will test all four Workshop batteries together. The 1-1/2 Volt Tester will test one Workshop battery at a time. Use these Testers to check the Workshop batteries if an Experiment does not work.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
THREE 3" BLACK	R8	R9	
	R10	R11	
	B4	L1	
TWO 4" BROWN	B3	R7	
	N4	M1	
ONE 6" RED	L2	N4	
ONE 10" YELLOW	R12	M2	

6 VOLT TESTER OPERATION

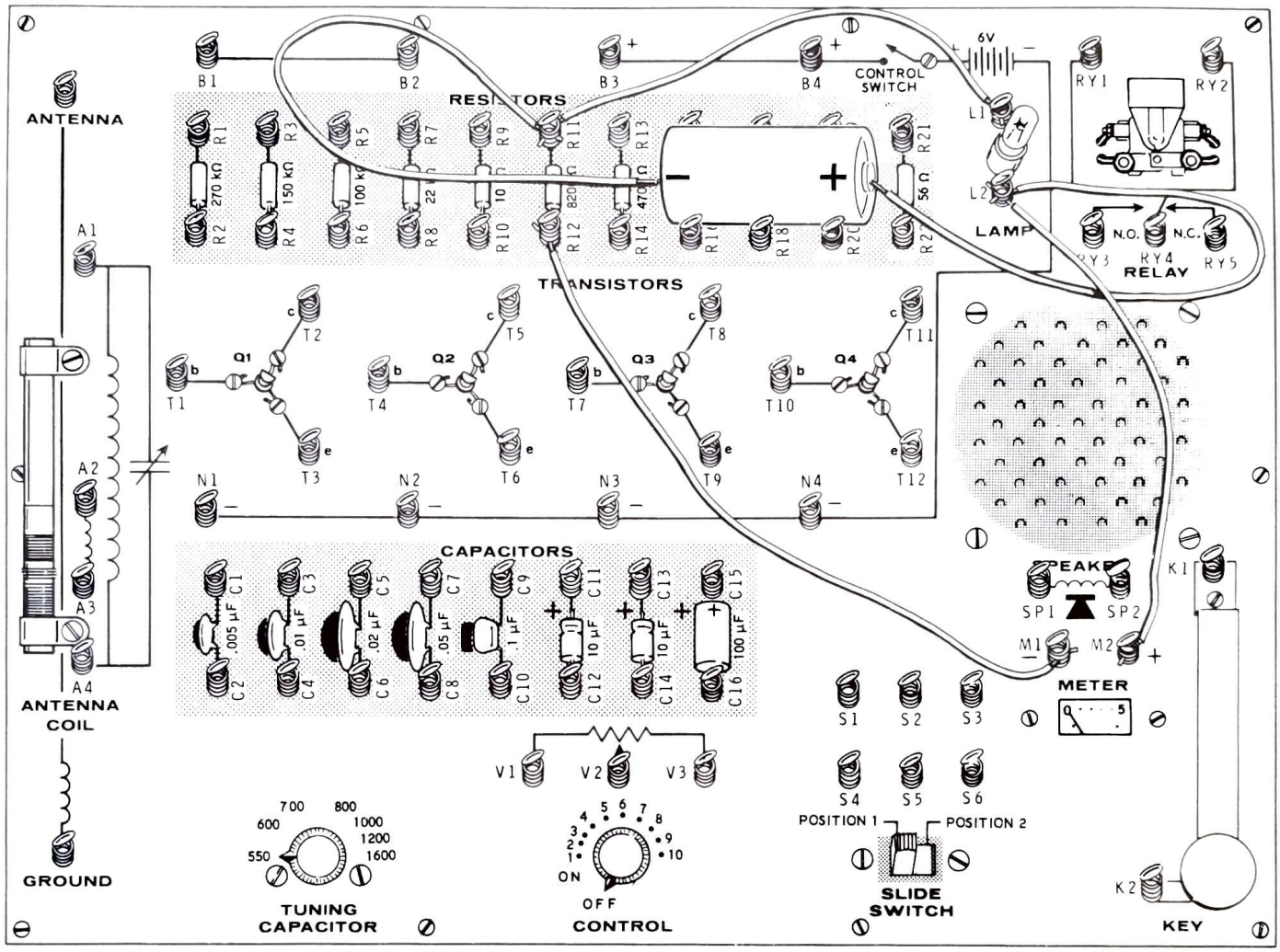
Turn the CONTROL to ON. The Lamp should light brightly and the Meter should read between 4 and 5 if the batteries are fresh. A Meter reading below 2-1/2 indicates weak batteries.

NOTE: If the Meter fails to read, refer to "In Case Of Difficulty" on Page 153.

If the Meter indicates that the batteries are weak, all of them may not need to be replaced. Use the following 1-1/2 volt tester to check each of the four batteries separately.

( ) Turn the CONTROL off and disconnect all wires.

1-1/2 VOLT TESTER



WIRING CHART			
USE	FROM	TO	
		FROM	TO
TWO 8" ORANGE	R11	L1	
	M2	L2	
ONE 10" YELLOW	M1	R12	
TEST PROBES			
TWO 14" BROWN	L2	(+) BATT. TERM.	
	R11	(-) BATT. TERM.	

1-1/2 VOLT TESTER OPERATION

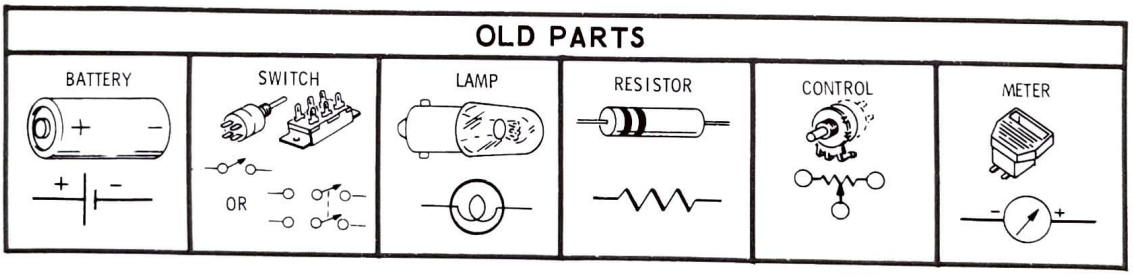
Position one of the Workshop batteries as shown. Turn the CONTROL to ON.

Touch the Test Probe from L2 to the positive battery terminal and the Test Probe from R11 to the negative battery terminal. The Lamp should light dimly and the Meter should read between 4 and 5. If the Lamp fails to light and the Meter reads less than 2-1/2, the battery should be replaced.

( ) Turn off the CONTROL.

( ) Reinstall the batteries.

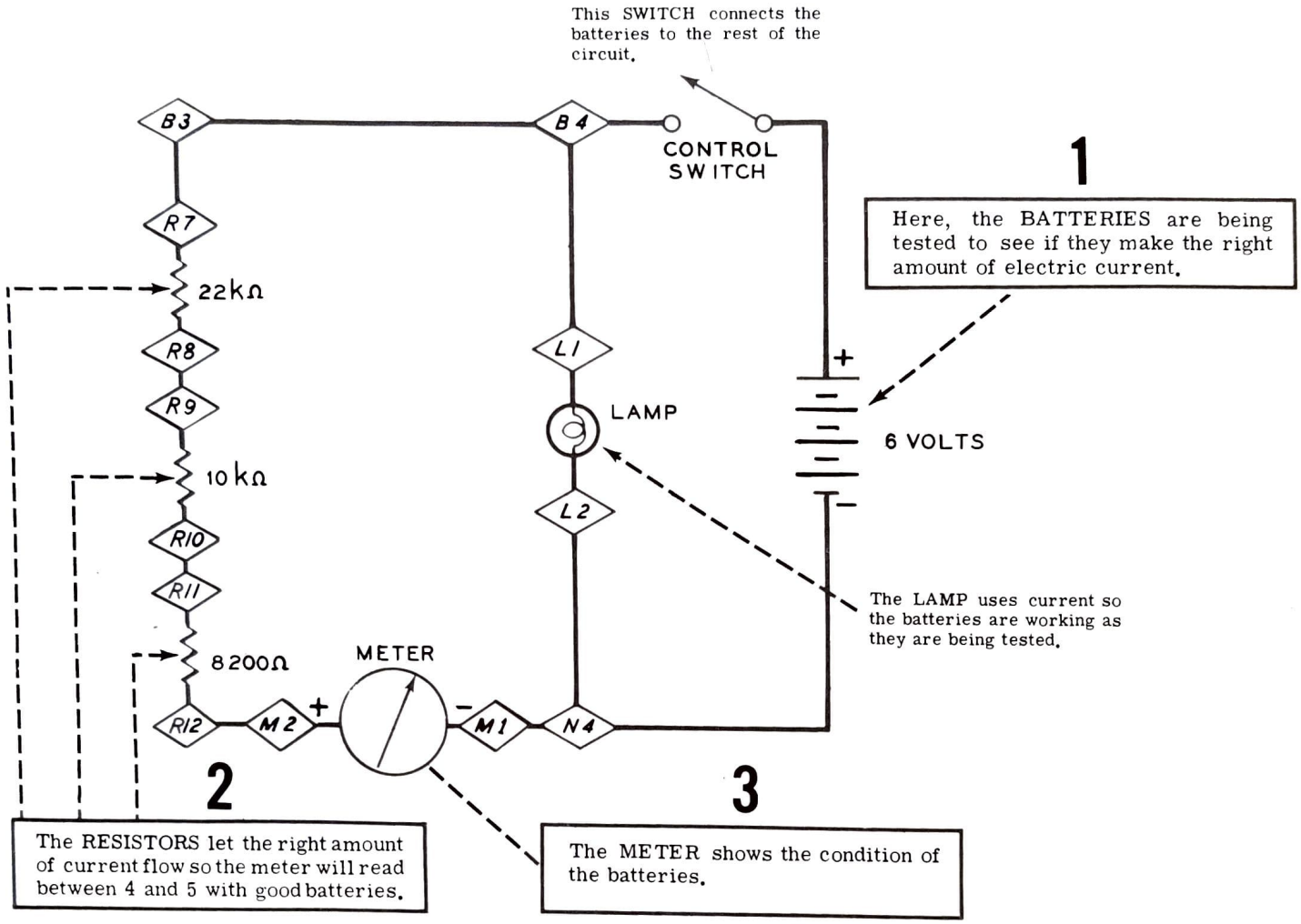
PARTS



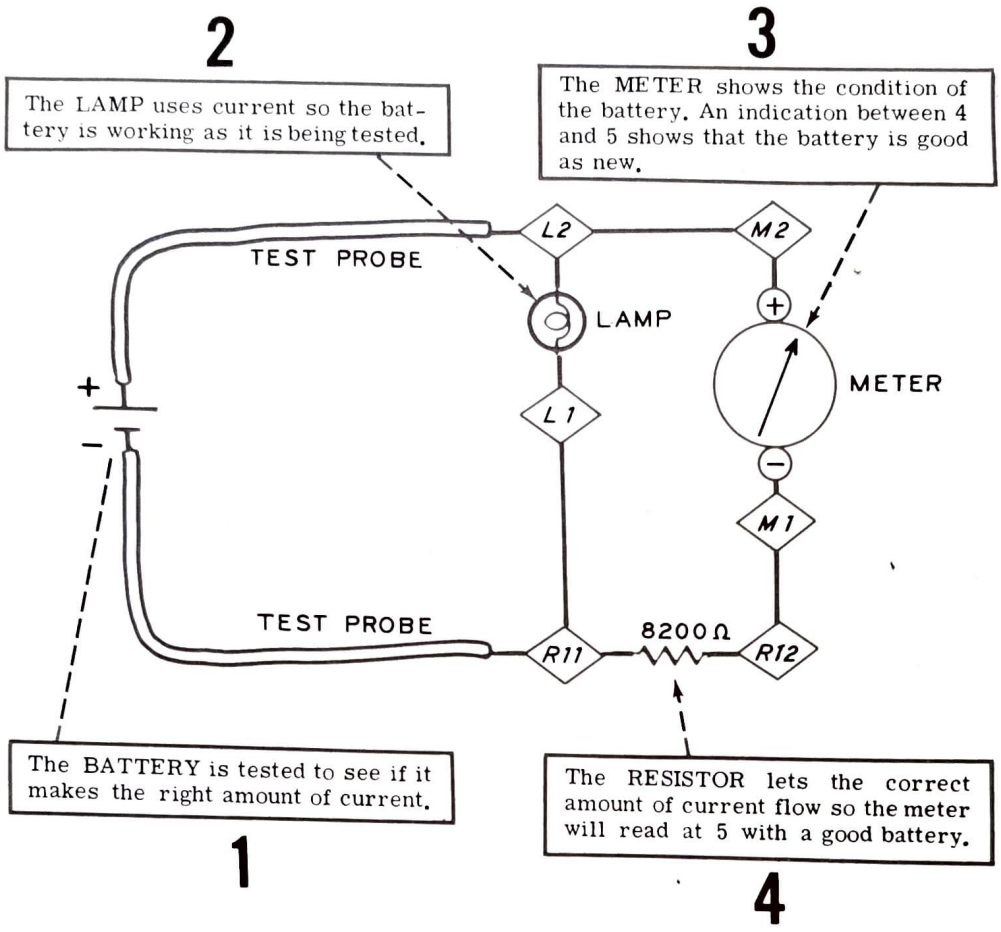
THEORY NOTE: Current is pushed thru a circuit by electrical pressure. This pressure is called "voltage."

There is 1-1/2 volts of electrical pressure in each of your batteries. When all four batteries are used in this manner, the voltages add together, producing a total pressure of 6 volts.

WHAT HAPPENS IN THE CIRCUIT



6 Volt Tester



1-1/2 Volt Tester

THINGS TO DO AFTER THE EXPERIMENT

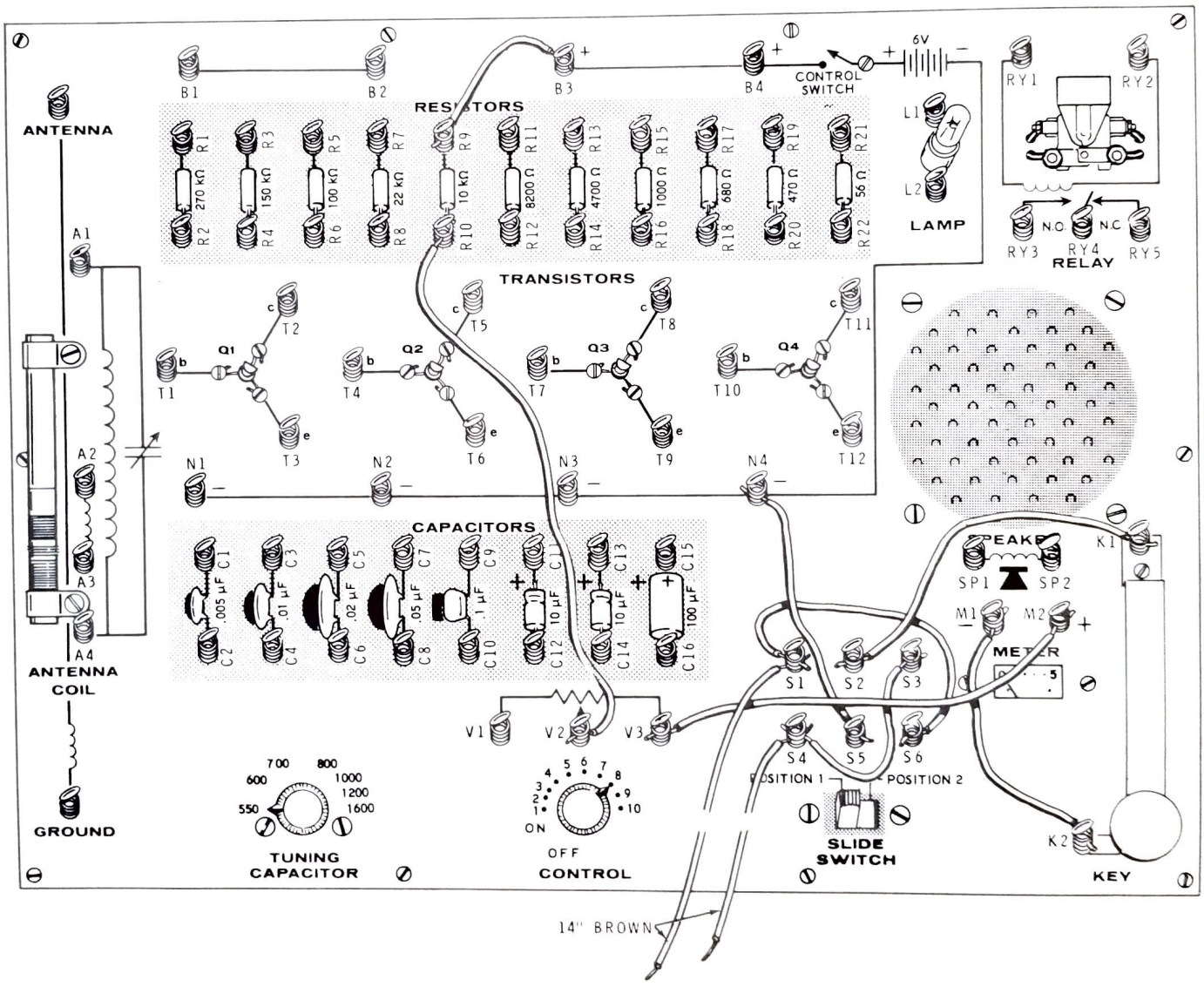
You may also use the 1-1/2 Volt Tester to check other 1-1/2 volt type "D" and type "C" batteries. DO NOT use this tester to check batteries of more than 1-1/2 volts. This could seriously damage your Workshop.

EXPERIMENT 4

Diode Tester

In this Experiment you will see how a diode affects an electric current that tries to flow thru it. Actually, there are no diodes in your Electronic Workshop. Therefore, you will use 1/2 of a transistor as a diode. A transistor, in simple terms, is like two diodes in one container.

The Slide Switch will be used in this Experiment. When you push this Switch from one position to the other, it will do the same thing in the Tester that you would do by switching the positions of the Test Probes. This will make current go both ways thru what you are testing, one way for each switch position.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
TWO 3" BLACK	B3	R9	
	S4	S3	
THREE 4" BROWN	S5	N4	
	M1	K2	
	S1	S6	
TWO 6" RED	K1	S2	
	V3	M2	
ONE 8" ORANGE	V2	R10	
TEST PROBES			
TWO 14" BROWN		S1	
		S4	

OPERATION

( ) Position the two Test Probes so they do not touch each other or any other metal object.

( ) Turn the CONTROL to 8.

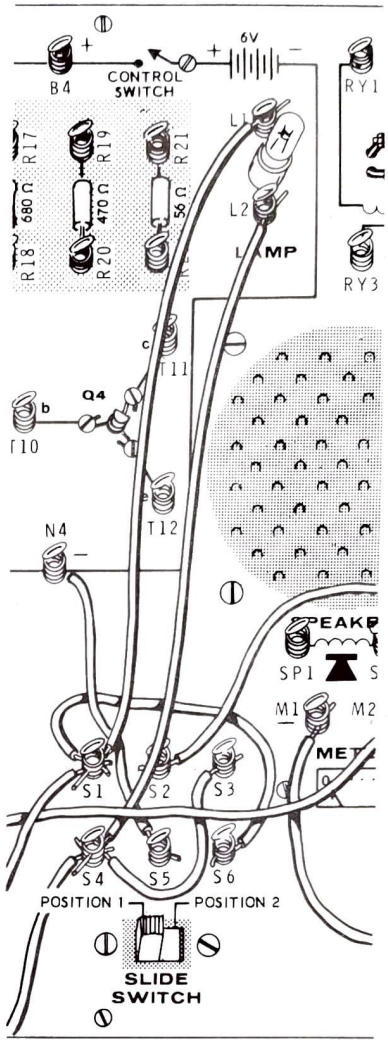
( ) Press the KEY and push the SLIDE SWITCH back and forth. Note that there is no meter reading now, since no current can get from one lead to the other.

( ) Press the KEY, touch the two Test Probes together, and adjust the CONTROL until the pointer is at 5 on the Meter.

Checking A Lamp With The Tester

( ) Refer to Pictorial 4-4B and connect the loose end of the Test Probe coming from S1 to L1.

( ) Connect the loose end of the Test Probe coming from S4 to L2.



PICTORIAL 4-4B

The Lamp is now connected to the Tester circuit. (The Lamp will not light, though, because not enough current is going thru it.)

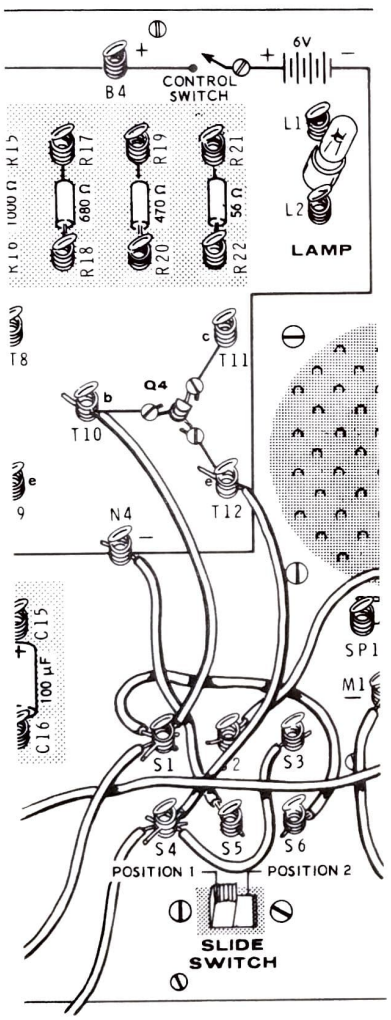
( ) Press the KEY to turn on the Tester, and push the SLIDE SWITCH back and forth. Note that the Meter reads at the same place in both SWITCH positions. This indicates that the same amount of current goes thru the Lamp in each direction.

CHECKING A DIODE (E to B on Q4)

( ) Refer to Pictorial 4-4C. Then disconnect the Test Probe from L1 and connect it to T10.

( ) Disconnect the other Test Probe from L2 and connect it to T12.

( ) Press the KEY and push the SLIDE SWITCH back and forth. Note that the meter now reads in only one SWITCH position. This indicates that current will only go in one direction thru a diode.



PICTORIAL 4-4C

CHECKING A DIODE (C to B on Q4)

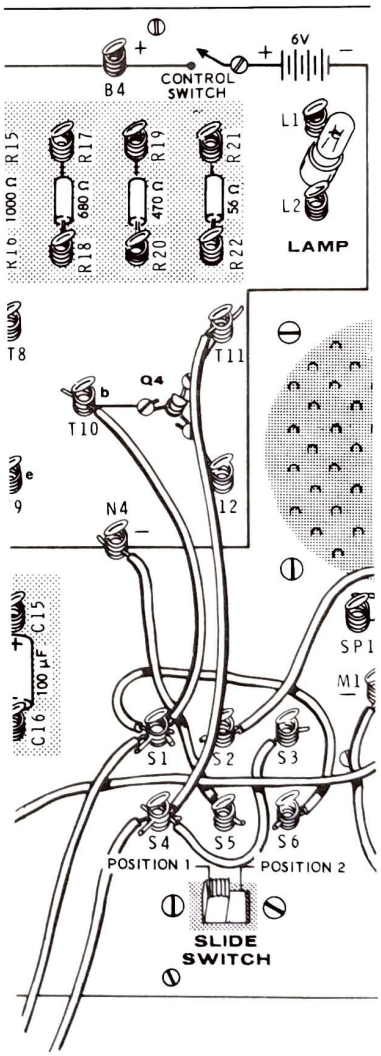
( ) Refer to Pictorial 4-4D. Then disconnect the Test Probe from T12 and connect it to T11.

( ) Press the KEY and push the SLIDE SWITCH back and forth. The meter should read in only one SWITCH position.

( ) Turn off the CONTROL.

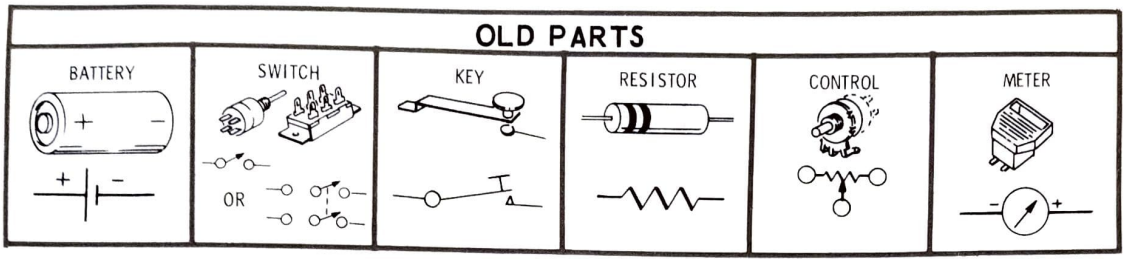
APPLICATIONS

You have just seen what happens when you test a good diode. The diode only passes current in one direction. If a diode were bad, either no current would flow either way (an "open" diode) or current would flow both ways (a "shorted" diode).



PICTORIAL 4-4D

PARTS



WHAT HAPPENS IN THE CIRCUIT

See the fold-out from this Page.

THINGS TO DO AFTER THE EXPERIMENT

You can also think of transistor Q1, Q2, or Q3 as two diodes. You can check the diode action between E and B or between B and C of any of these transistors. You can also check other diodes not in the Workshop, but they must be removed from the unit they are a part of before you can check them.

Diode Tester

2

Current should only flow thru a diode in one direction.

For Example: If the SLIDE SWITCH is in POSITION 1 and current flows thru the diode, current will not flow in POSITION 2 unless the diode is faulty (shorted).

The SLIDE SWITCH reverses the connections between the test probes and the diode. This changes the way the current tries to flow from the tester to the diode. You could do the same thing by reversing the positions of the test leads.

3

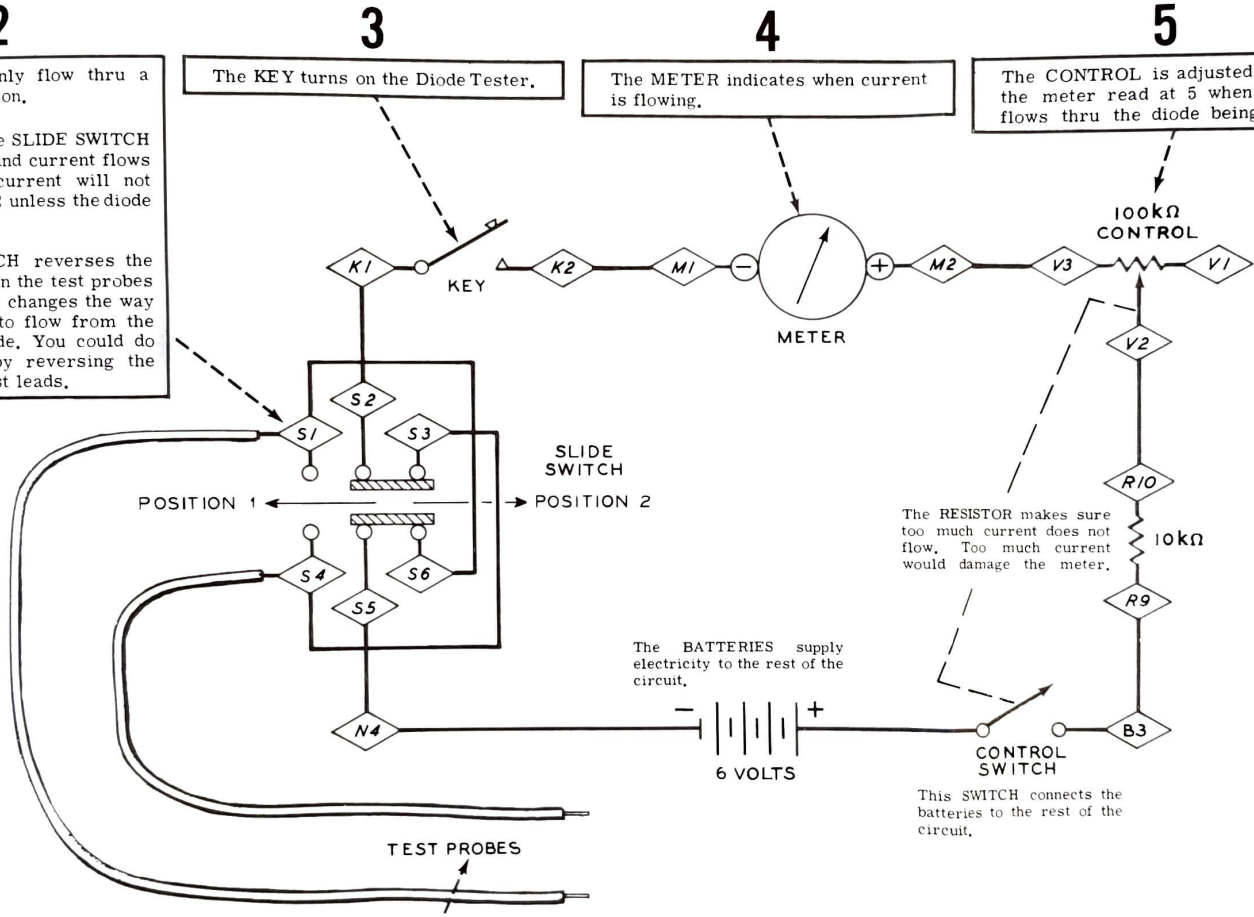
The KEY turns on the Diode Tester.

4

The METER indicates when current is flowing.

5

The CONTROL is adjusted to make the meter read at 5 when current flows thru the diode being tested.



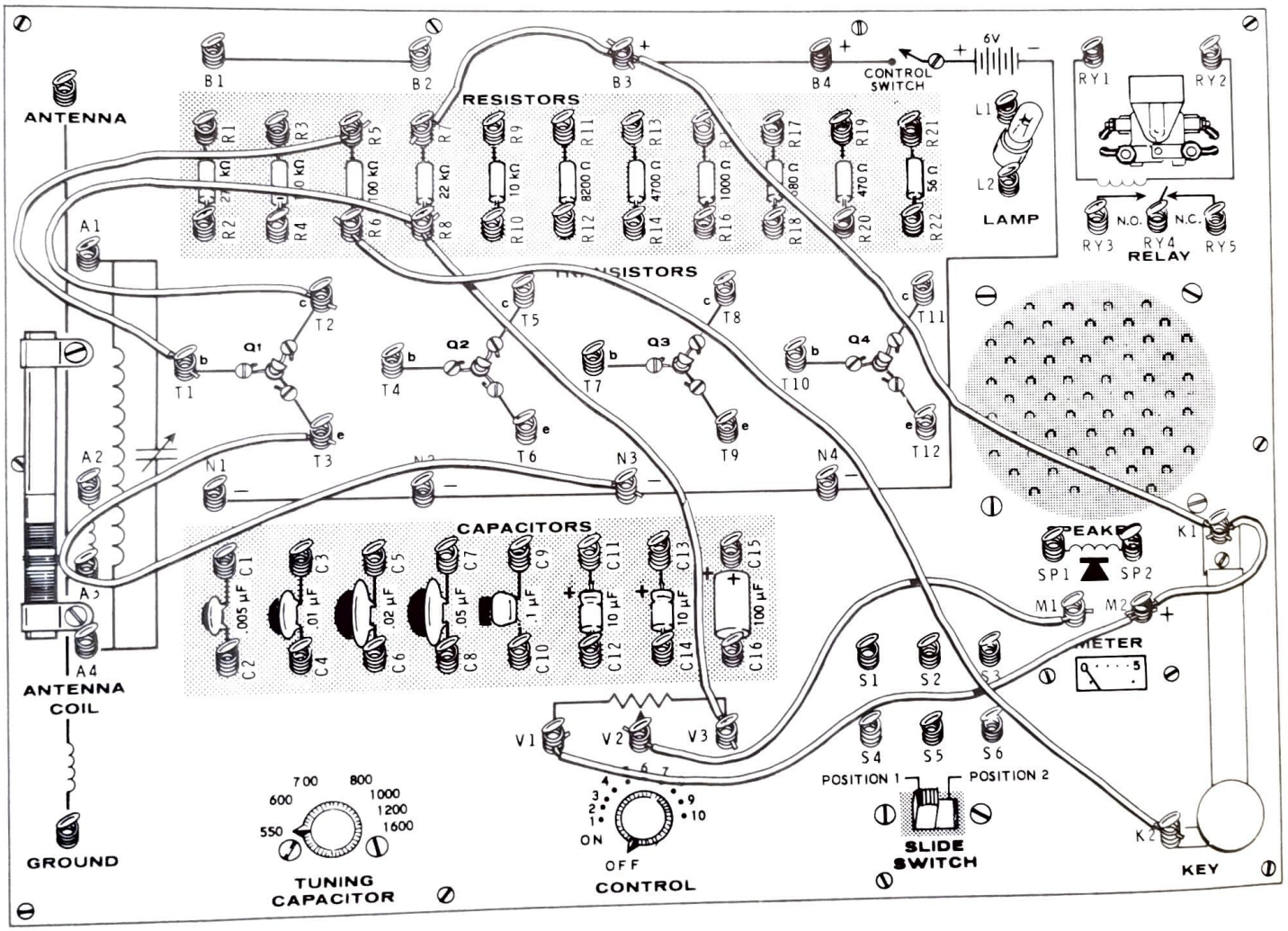
1

The TEST PROBES connect the Tester to the diode to be tested.

EXPERIMENT 5

Transistor Tester

This Transistor Checker may be used to check the transistors in the Workshop.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
ONE 3" BLACK	M2	K1	
ONE 4" BROWN	B3	R7	
ONE 8" ORANGE	V2	M1	
TWO 10"YELLOW	V1	M2	
	V3	R8	
ONE 12" BLACK	K1	B3	
ONE 14" BROWN	R6	K2	
TEST PROBES			
12" BLACK	N3		
14" BROWN	R8		
14" BROWN	R5		

CALIBRATION

( ) Connect the Test Probe coming from R8 to N2.

( ) Be sure the other two Test Probes do not touch each other.

( ) Turn the CONTROL to ON. Then increase the setting until the meter reads "5". Leave the CONTROL set at this position.

( ) Disconnect the Test Probe from N2.

( ) Connect this Test Probe to T2.

( ) Connect the Test Probe coming from R5 to T1.

( ) Connect the Test Probe coming from N3 to T3.

The Tester is now wired with the Test Probes connected to test Transistor Q1.

OPERATION

NOTE: You will test the transistor (Q1) when you press the KEY. The KEY lets current pass thru one-half of the transistor (between E and B). If the transistor is good, this will make current go thru the other half of the transistor (between E and C) and the Meter.

( ) Push the KEY; the Meter pointer should move to 5. This indicates that the transistor is good. Release the KEY, the Meter pointer should go back to 0.

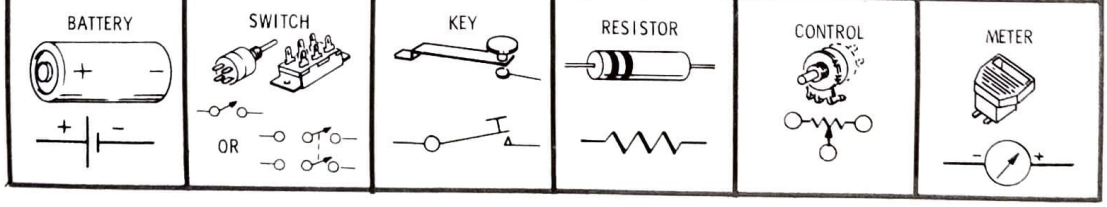
You can also test the other transistors on your Workshop. Just connect the Test Probes as follows:

TO CHECK TRANSISTOR	CONNECT THE TEST PROBE COMING FROM		
	R5 to:	R8 to:	N3 to:
Q2	T4	T5	T6
Q3	T7	T8	T9
Q4	T10	T11	T12

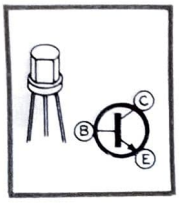
( ) Turn off the control.

PARTS

OLD PARTS

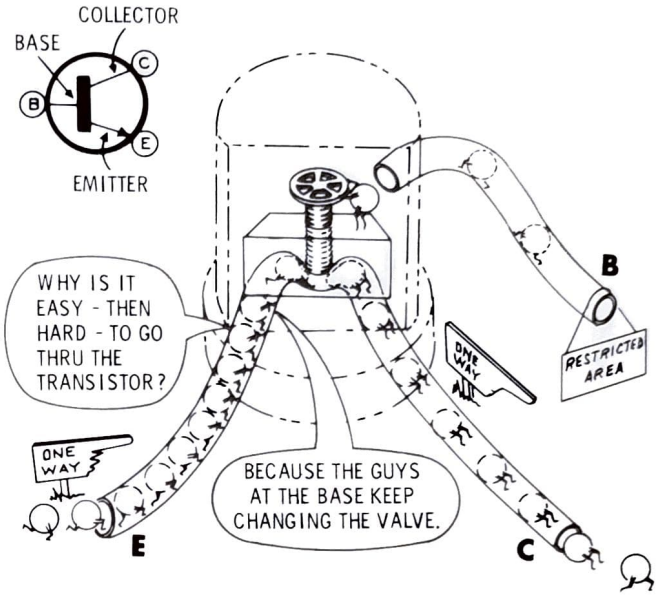


NEW PARTS



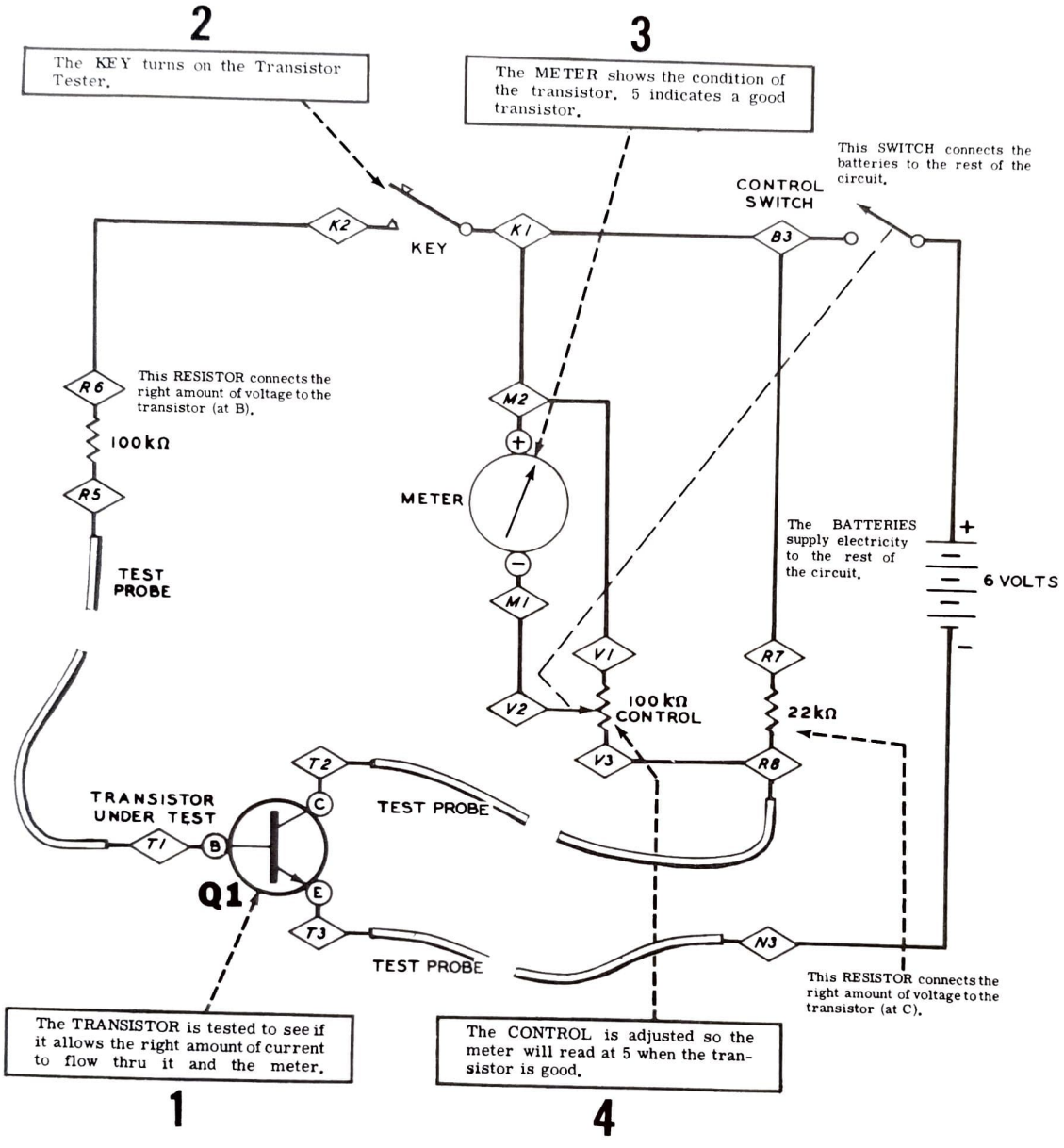
TRANSISTOR - Most transistors have three parts: an emitter, a base, and a collector. A small amount of electric current at the base (B) can control a large current flowing between the emitter (E) and collector (C). This (B) is something like the valve (in the faucet) that lets water flow (E to C) thru your garden hose.

THEORY NOTE: To operate properly, many parts (like transistors for example) must have a particular amount of voltage (electrical presure, see the "Theory Note" on Page 41) at each terminal. The design engineer gets the right amount of voltage at each terminal by using resistors of just the right size. The resistor uses up some of the pressure.



TRANSISTOR

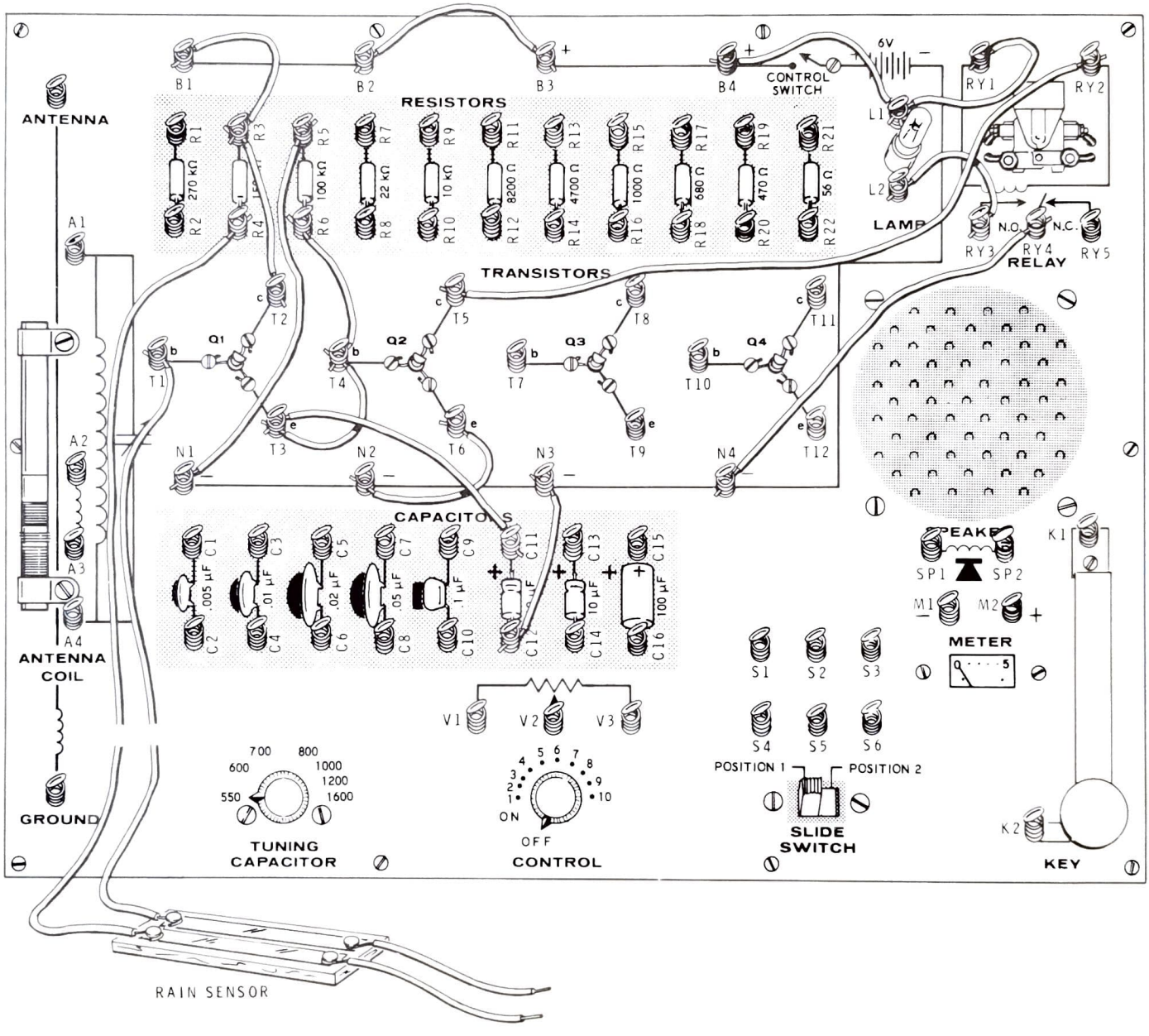
WHAT HAPPENS IN THE CIRCUIT



EXPERIMENT 6

Rain Alarm

This Rain Alarm circuit will turn on a Lamp when the rain sensor gets wet.



Many of these Experiments will use all three columns in the Wiring Chart. The first line on the Chart below, for example, calls for two 3" wires by listing connecting points R6, T4, and T3. This means to connect one 3" wire from R6 to T4 and another 3" wire from T4 to T3.

WIRING CHART			
USE	FROM	TO	
		FROM	TO
NINE 3"BLACK	R6	T4	T3
	T2	R3	B1
	B2	B3	
	RY1	L1	B4
	L2	RY3	
	T6	N2	
TWO 4" BROWN	N3	C12	
	C11	T3	
ONE 6" RED	R5	N1	
ONE 8" ORANGE	RY4	N4	
ONE 10" YELLOW	RY2	T5	
25' WHITE	R4		
25' WHITE-BLUE	T1		

OPERATION

MAKING A RAIN SENSOR

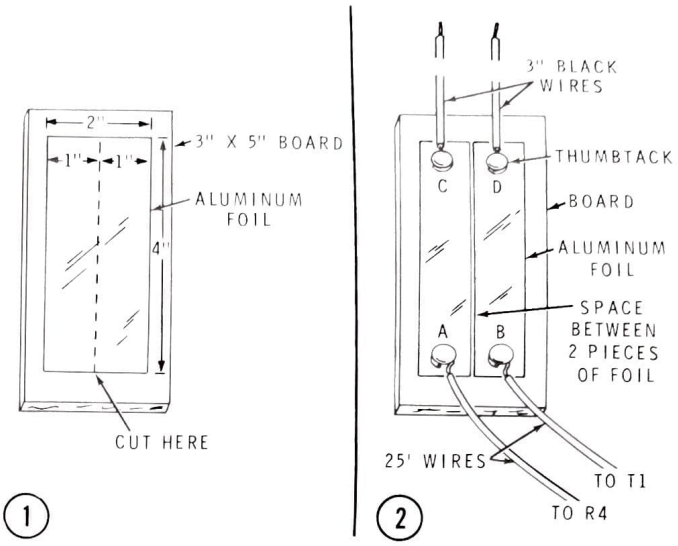
( ) Get a small piece of wood about 3" wide by 5" long.

( ) Obtain a 2" wide by 4" long piece of aluminum foil (such as used for cooking purposes).

( ) Cut the foil up the center as shown in illustration #1 above.

( ) Place the two foil pieces on the board and leave a space between them that is equal to the width of a piece of hook-up wire.

( ) Push thumbtacks thru the ends of the foil strips and partially into the board.



( ) Connect the 25 foot white wire coming from R4 to the thumbtack at A.

( ) Connect the 25 foot white-blue wire coming from T1 to the thumbtack at B.

( ) Press thumbtacks A and B down so the wires are tight against the foils.

( ) Connect a 3" black wire to the tack at C.

( ) Connect a 3" black wire to the tack at D.

( ) Press tacks C and D down so they are tight. Be sure the 3" black wires are straight and do not touch each other.

TESTING

( ) Turn the CONTROL to position 1. The Lamp should not light. If the Lamp does light, the foil pieces or the 3" wires are touching each other and should be separated.

( ) Moisten your finger and touch the two aluminum foil pieces at the same time. The Lamp should light.

( ) Remove your finger. The Lamp should go out.

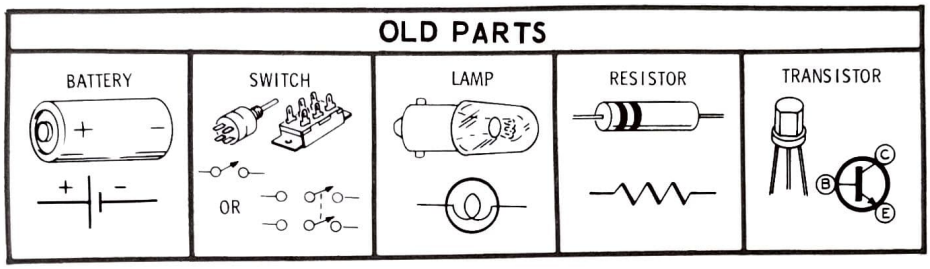
( ) Turn off the CONTROL.

USING THE RAIN ALARM

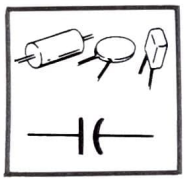
Place the sensor out the window or wherever you want to check for water. Your rain sensor is now ready for use. The Lamp will light whenever the rain sensor gets moisture on it (rain, snow, dew, mist, fog).

The uses of the rain alarm are not limited to just detecting rain or snow. For example, if you are filling a tub or wading pool and the water turn-off is not near, you can put the sensor in the tub or pool at the height you want the water to be. Then the Lamp will light when the water reaches the 3" black sensor wires.

PARTS



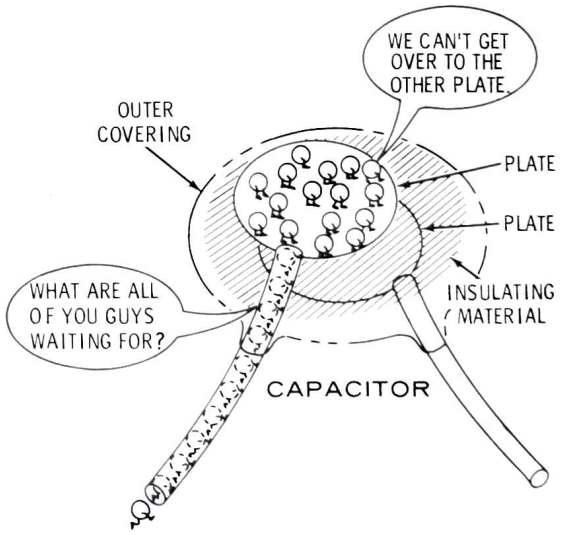
NEW PARTS

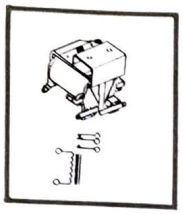


CAPACITOR - A capacitor has two sides, called plates, that are not electrically connected to each other. (An insulating material keeps the plates from touching each other.)

Electrons can pile up and be stored up on one plate, but they cannot get thru to the other plate. A current can get thru a capacitor only if its electrons pile up and unpile quickly (as they pile up on one plate, they make electrons leave the other plate).

Current from a battery does not pass thru a capacitor; the electrons just pile up on one of the plates and stay there. But the currents in a signal do pass thru a capacitor because they are always changing. This lets the electrons pile up and unpile quickly on the plates.

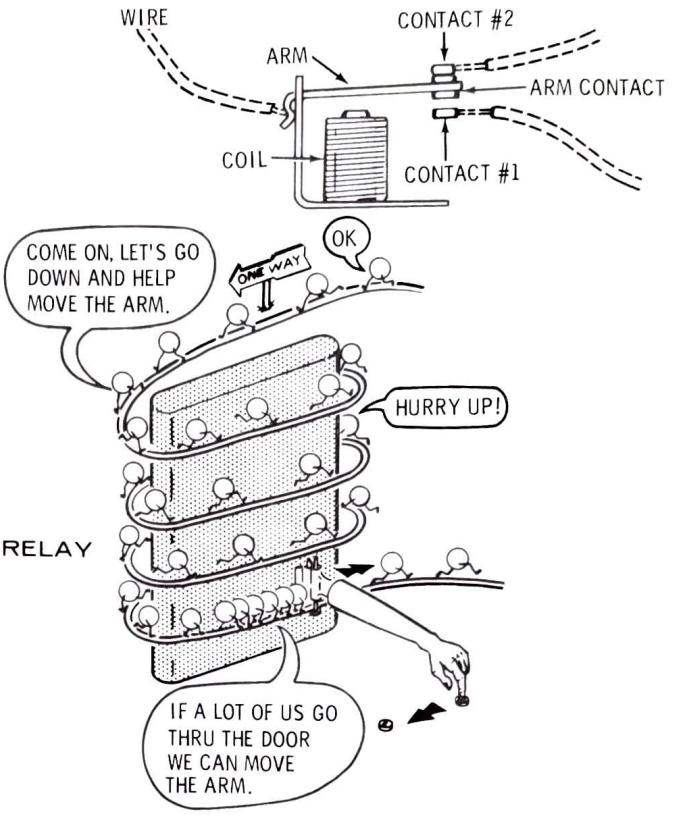


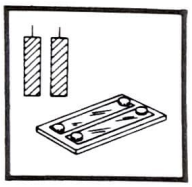


RELAY - When current goes thru its coil, a relay acts like a magnet. The coil then pulls a steel arm down against it.

This arm acts like a switch. With no current in the coil, the arm contact touches contact #2. When the arm is pulled down, the arm contact touches contact #1.

NOTE: "N O" is printed on the Workshop board between RY3 and RY4. These initials mean that these two contacts are "Normally Open" (not touching) when no current is flowing in the relay coil. The initials "N C", between RY4 and RY5, mean that these two contacts are "Normally Closed" (touching) when no current is flowing in the relay coil.



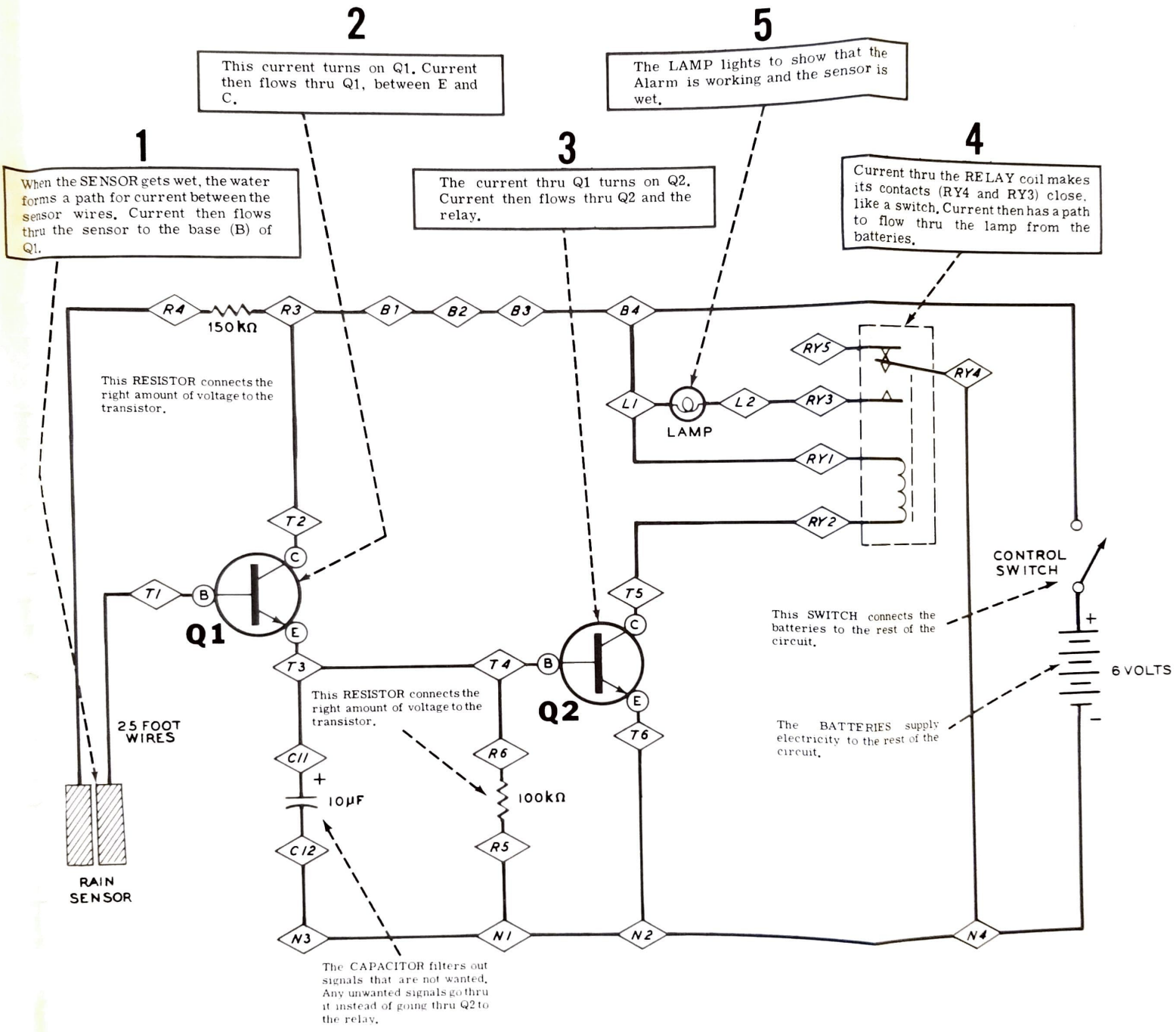


SENSOR - When the sensor gets wet, current flows thru the water from one foil to the other.

WHAT HAPPENS IN THE CIRCUIT

See the fold-out from this Page.

Rain Alarm


2
This current turns on Q1. Current then flows thru Q1, between E and C.
5
The LAMP lights to show that the Alarm is working and the sensor is wet.
1
When the SENSOR gets wet, the water forms a path for current between the sensor wires. Current then flows thru the sensor to the base (B) of Q1.
3
The current thru Q1 turns on Q2. Current then flows thru Q2 and the relay.
4
Current thru the RELAY coil makes its contacts (RY4 and RY3) close, like a switch. Current then has a path to flow thru the lamp from the batteries.
R4
150kΩ
R3
B1
B2
B3
B4
This RESISTOR connects the right amount of voltage to the transistor.
RY5
RY4
L1
L2
RY3
LAMP
RY1
RY2
T2
C
T1
B
Q1
E
T3
T4
B
T5
C
Q2
E
T6
CONTROL SWITCH
This SWITCH connects the batteries to the rest of the circuit.
+
6 VOLTS
−
This RESISTOR connects the right amount of voltage to the transistor.
25 FOOT WIRES
C11
+
10μF
C12
R6
100kΩ
R5
The BATTERIES supply electricity to the rest of the circuit.
RAIN SENSOR
N3
N1
N2
N4
The CAPACITOR filters out signals that are not wanted. Any unwanted signals go thru it instead of going thru Q2 to the relay.

Timing Relay

1

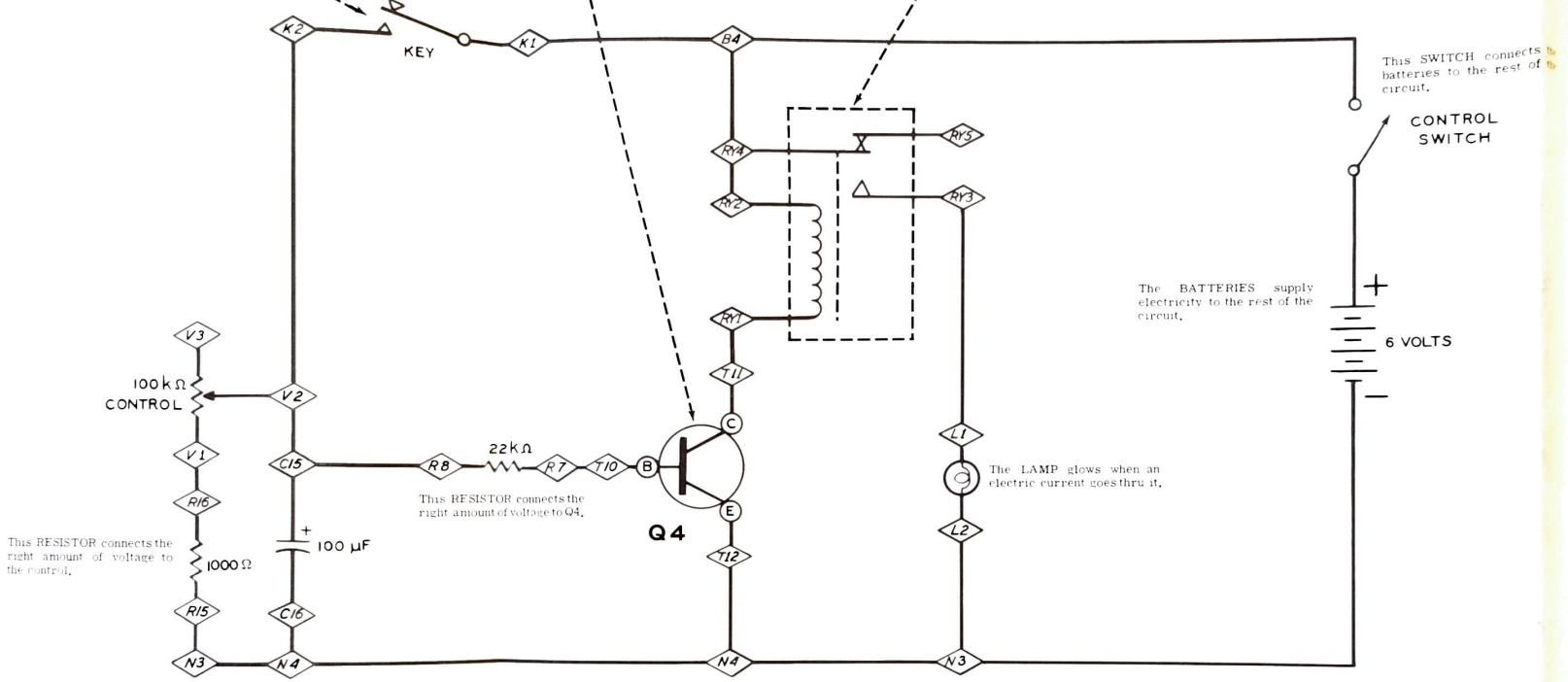
When the KEY is closed, current flows thru it to the capacitor, control, and 22 kΩ resistor.

2

The current flowing in the 22 kΩ RESISTOR turns on TRANSISTOR Q4. Battery current then flows thru Q4 (between E and C) and thru the relay.

3

Current thru the RELAY makes its contacts (RY4 and RY3) close, like a switch. Current then has a path to flow thru the LAMP from the batteries.



This SWITCH connects batteries to the rest of the circuit.

The BATTERIES supply electricity to the rest of the circuit.

The LAMP glows when an electric current goes thru it.

This RESISTOR connects the right amount of voltage to Q4.

This RESISTOR connects the right amount of voltage to the control.

4

After the KEY is released, the piled-up electrons flow from one capacitor plate to the other thru the control and 1000 Ω resistor, and thru the 22 kΩ resistor and transistor (between B and E).

This capacitor current makes the battery current keep flowing thru the transistor and relay until most of the electrons reach the other plate.

5

When you set the CONTROL for more resistance, it will take the capacitor current longer to flow from one plate to the other (thru the CONTROL and resistor). This will make current flow in Q4 and the relay for a longer time (and keep the lamp lit for a longer time).

WIRING CHART			
USE	FROM	TO	
		FROM	TO
TWO 3" BLACK	RY2	RY4	
	N4	T12	
THREE 4" BROWN	V2	C15	
	C16	N4	
	RY3	L1	
FOUR 6" RED	RY2	B4	
	RY1	T11	
	R15	N3	
	R7	T10	
FOUR 8" ORANGE	V1	R16	
	K2	V2	
	L2	N3	
	R8	C15	
ONE 10" YELLOW	B4	K1	

OPERATION

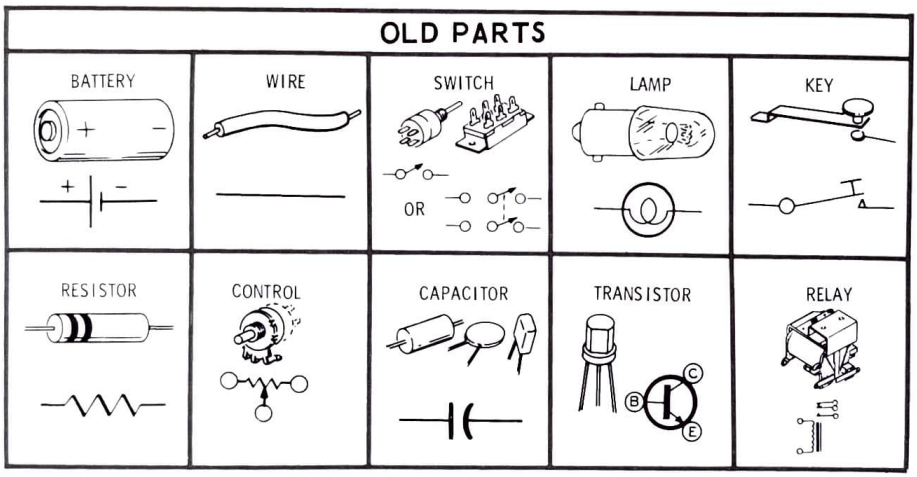
( ) Turn the CONTROL to ON.

( ) Push the KEY and release it. The Lamp will light and remain on for a short time.

( ) Turn the CONTROL clockwise to position 5 and push the KEY. Now the Lamp will light and stay on for a longer time. With the CONTROL fully clockwise the Lamp should light for about 6 seconds.

( ) Turn off the CONTROL.

PARTS

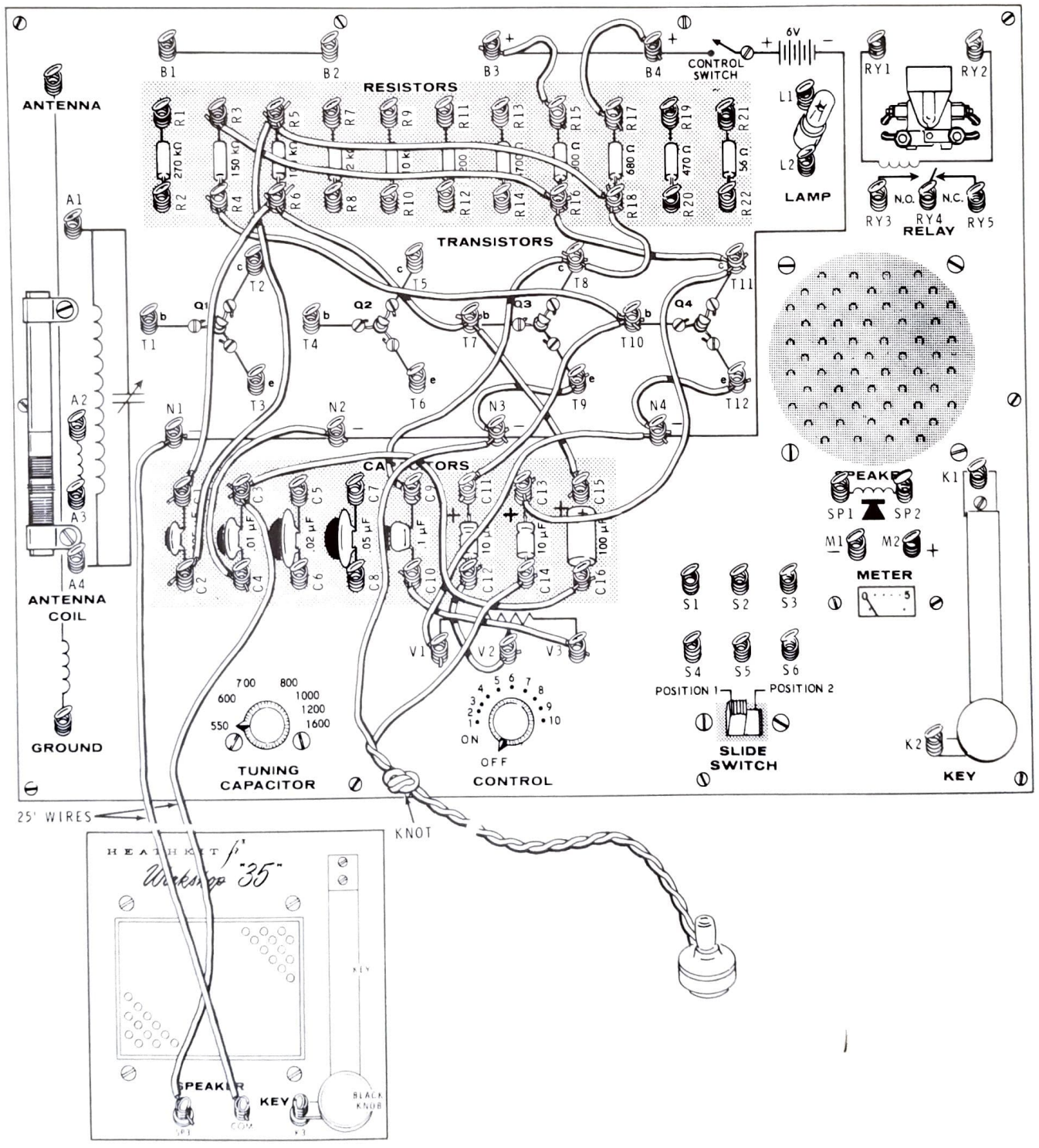


WHAT HAPPENS IN THE CIRCUIT

See the fold-out from Page 56.

EXPERIMENT 8
Listening Device

This Listening Device will let you stay in one room and listen to what is going on in another. Listening devices, usually very small ones, are sometimes used by detectives.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
SIX 3" BLACK	R15	B3	
	R17	B4	
	R18	T8	
	T9	N3	
	N4	T12	
	V2	C12	
SIX 4" BROWN	R6	T7	C15
	C11	T10	
	C4	N2	
	R16	T11	
	V3	C10	
SIX 6" RED	R3	R16	
	R5	R18	
	N4	V1	
	C9	T8	
	T11	C13	
	R6	C1	
THREE 8" ORANGE	R4	T10	
	C3	C16	
	C2	R5	
25' WHITE	C3	SP3 }	REMOTE
25' WHITE-BLUE	N1	COM. }	STATION

OPERATION

( ) Tie a knot in the earphone cable about 6" from the wire ends. This will keep the two wires from unravelling.

( ) Connect the Earphone wires to N3 and C14.

( ) Put the Earphone in your ear and turn the CONTROL to position 7.

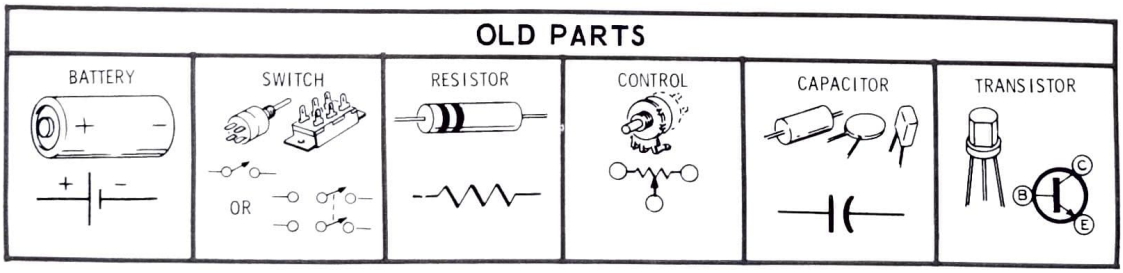
( ) Speak into the Remote Station. You should be able to hear your voice from the Earphone at the Workshop base. The Listening Device is now checked and ready for use.

( ) Place the Remote Station in the room where you want it to listen. You may want to place it out of sight.

( ) Turn the CONTROL on the Workshop up until the volume is high enough for you to hear what is going on.

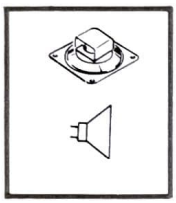
( ) Turn off the CONTROL when you complete the Experiment.

PARTS



NEW PARTS

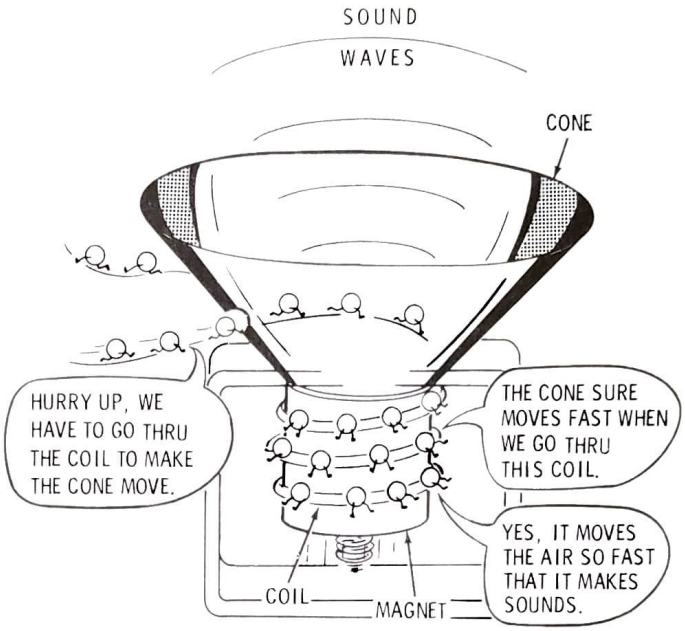
THEORY NOTE: The sound of your voice is changed into an electric current when it is applied to a circuit. Electric currents like this are called "signals". These "signals" are usually made by a microphone (but this can also be done with a speaker).



SPEAKER - A speaker (used normally) changes electrical signals into sounds.

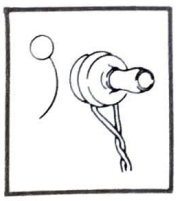
Speakers consist of a magnet, and a coil that is glued to a paper cone. When current goes through the coil, it makes magnetism. The magnetism from this coil pushes against the magnetism from the magnet, and this pushing moves the paper cone back and forth. The moving cone moves the air around it, and when these movements of air strike our ears, we hear them as sounds.

In this circuit, the speaker is used backwards. Sounds make the paper cone and coil move. When the coil moves, the magnetism from the magnet makes electric current flow in the coil. This electric current becomes the signal.

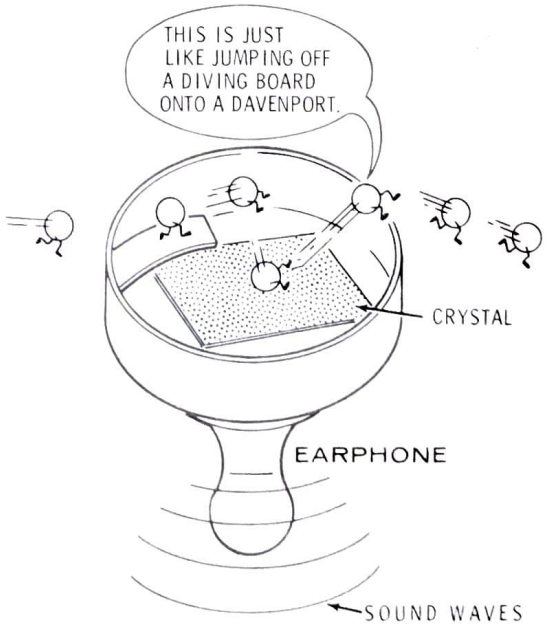


SPEAKER

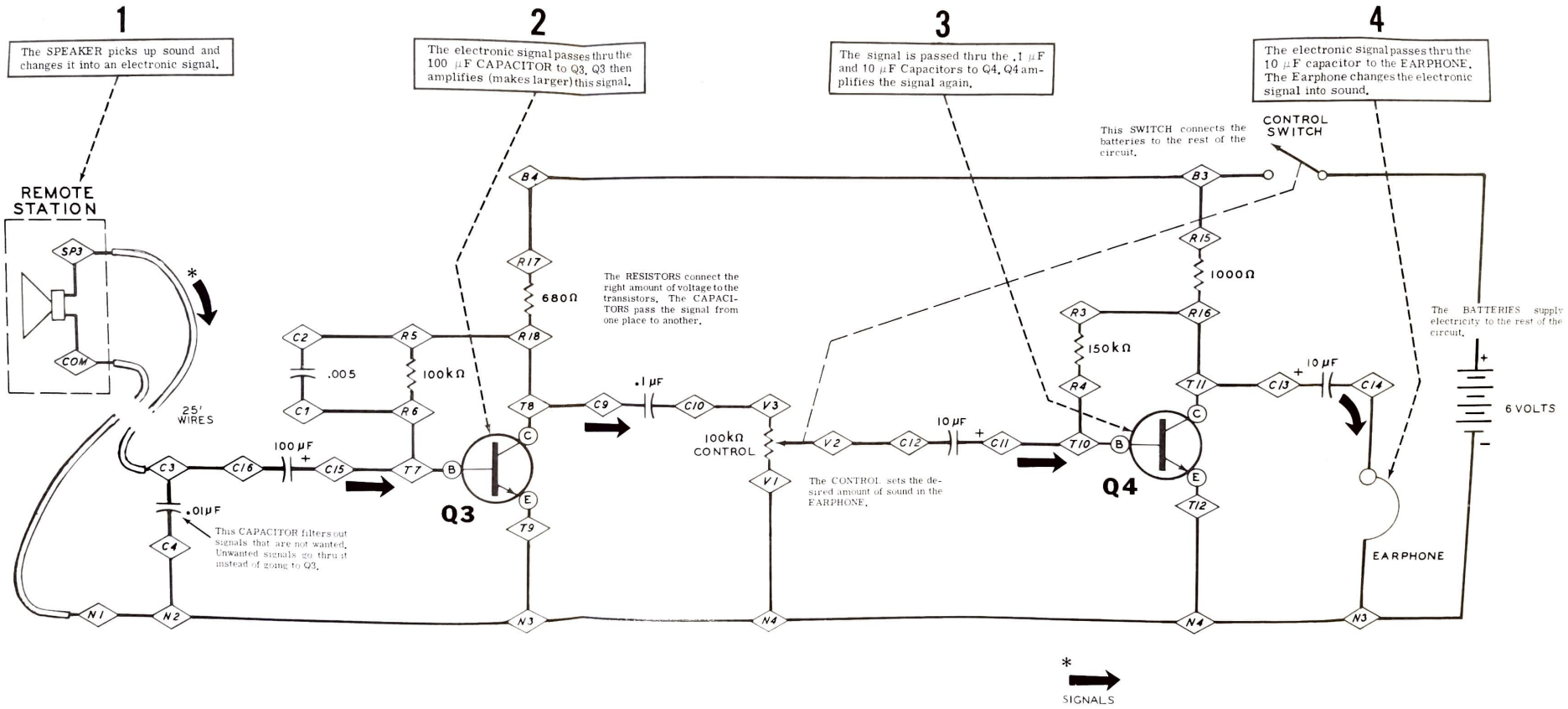
THEORY NOTE: Often, a Transistor is used to "amplify". This means it will make a small signal much larger. The small signal is connected to the base (B) of the Transistor. The transistor then acts like a valve, since this small signal at the base (B) controls a larger current that flows thru the transistor between the emitter (E) and collector (C). This makes the large signal at the collector look just like the small signal at the base. A transistor that is used like this, to make a small signal larger, is called an "amplifier".



EARPHONE - An Earphone also changes electrical signals into sounds. The signal is connected to a "crystal" in the Earphone. The signal makes the crystal bend back and forth. When the crystal bends, it pushes air back and forth and makes sounds.



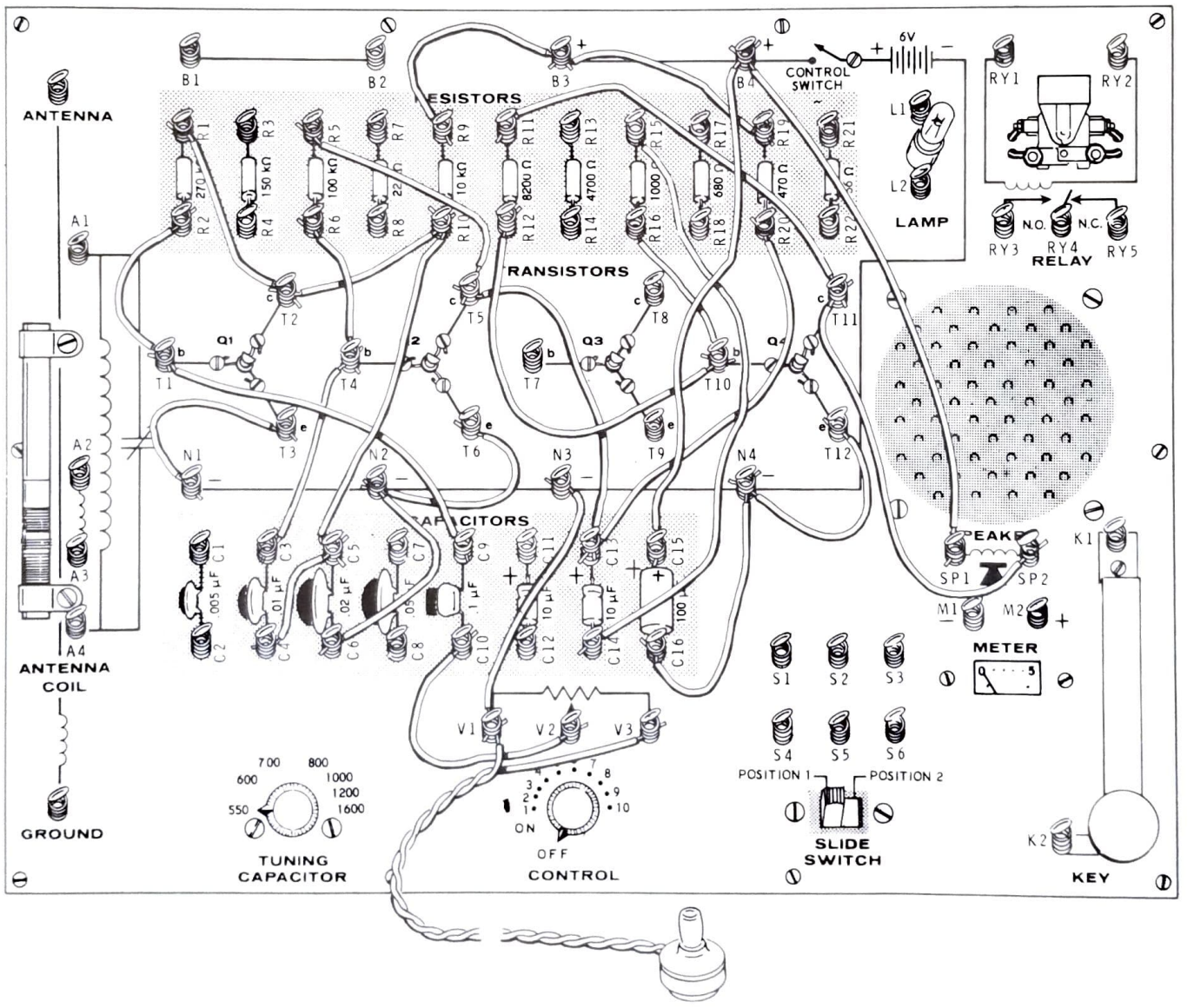
Listening Device



EXPERIMENT 9

Public Address Amplifier

This Experiment will show you what a Public Address (or "P. A.") Amplifier is like. Amplifiers like this are used (with a microphone and speaker) when someone wants to speak to a large crowd, as in a Church for instance.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
THIRTEEN 3" BLACK	R1	T2	R10
	T1	R2	
	R6	T4	
	C6	N2	T6
	T12	N4	C16
	C5	C4	
	R9	B3	
	N1	T3	
	C10	V2	
	R16	T10	
FIVE 4" BROWN	B3	R19	
	V1	N3	
	R5	T5	
	T4	C3	
	R12	T10	
SIX 6" RED	T5	C13	R20
	C9	T1	
	C5	R10	
	R11	T11	SP2
THREE 8" ORANGE	SP1	B4	C15
	C14	R15	
EARPHONE	V1	V3	

OPERATION

( ) Extend the Earphone wires so the Earphone is as far away from the Workshop as possible.

NOTE: The Earphone will be used as a microphone in this Experiment.

( ) Hold the Earphone close to your mouth with the open end toward you.

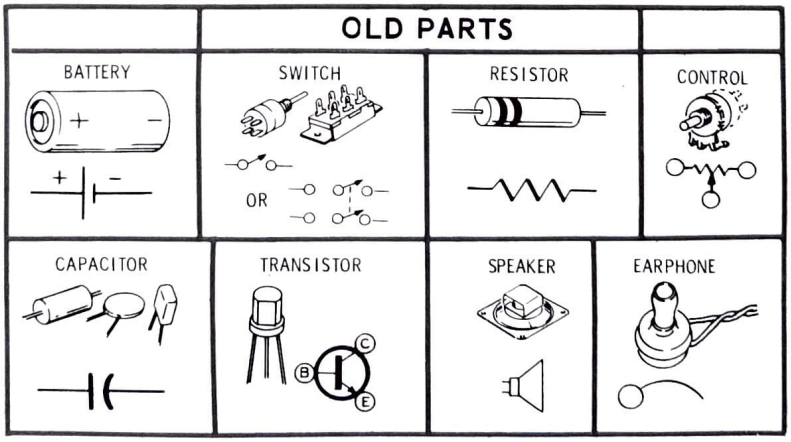
( ) Turn the CONTROL clockwise, while talking, until the sound from the speaker becomes distorted. Then turn the CONTROL back the other way just far enough to clear up the sound. This is the loudest point at which you can set the CONTROL.

Your Public Address Amplifier is ready to use. Now talk or sing into the earphone and hear yourself from the speaker. Try different noises and see how they sound.

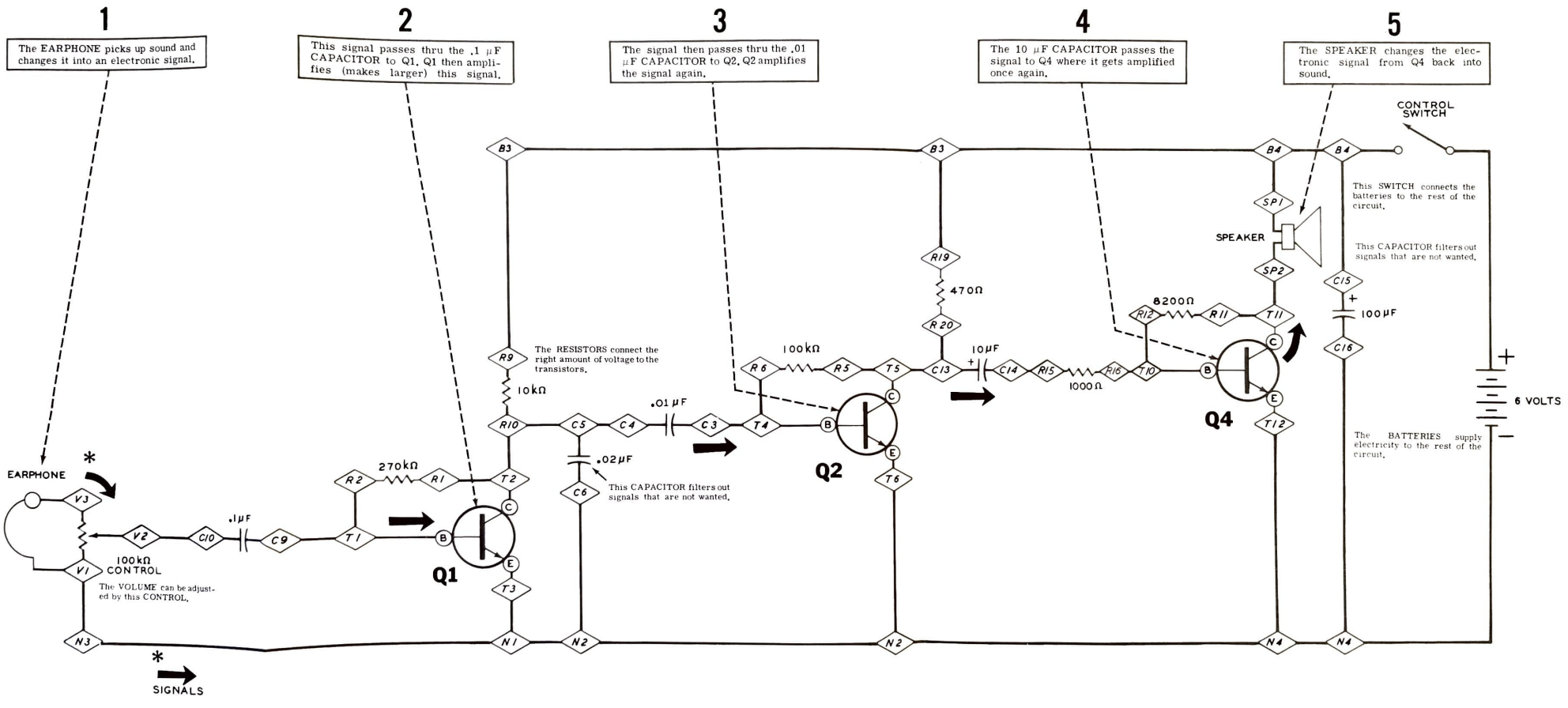
( ) Turn off the CONTROL when you complete the Experiment.

THEORY NOTE: An Earphone, like a speaker, can also be used backwards. When sounds hit the crystal, they make it bend back and forth. The crystal then makes an electric current, which is the signal.

PARTS



Public Address Amplifier



THINGS TO DO AFTER THE EXPERIMENT

You can also use your Public Address Amplifier to talk into other rooms. Just do the following steps to connect the Remote Station to the Amplifier instead of the speaker in the Workshop.

( ) Turn off the Control (completely counter-clockwise).

( ) Remove the 8" orange wire from SP1 to B4.

( ) Remove the 6" red wire from SP2 to T11.

( ) Attach a long wire from B4 to the COM terminal of the Remote Station.

( ) Connect a long wire from T11 to the SP3 terminal of the Remote Station.

Leave all the other wires connected as they are.

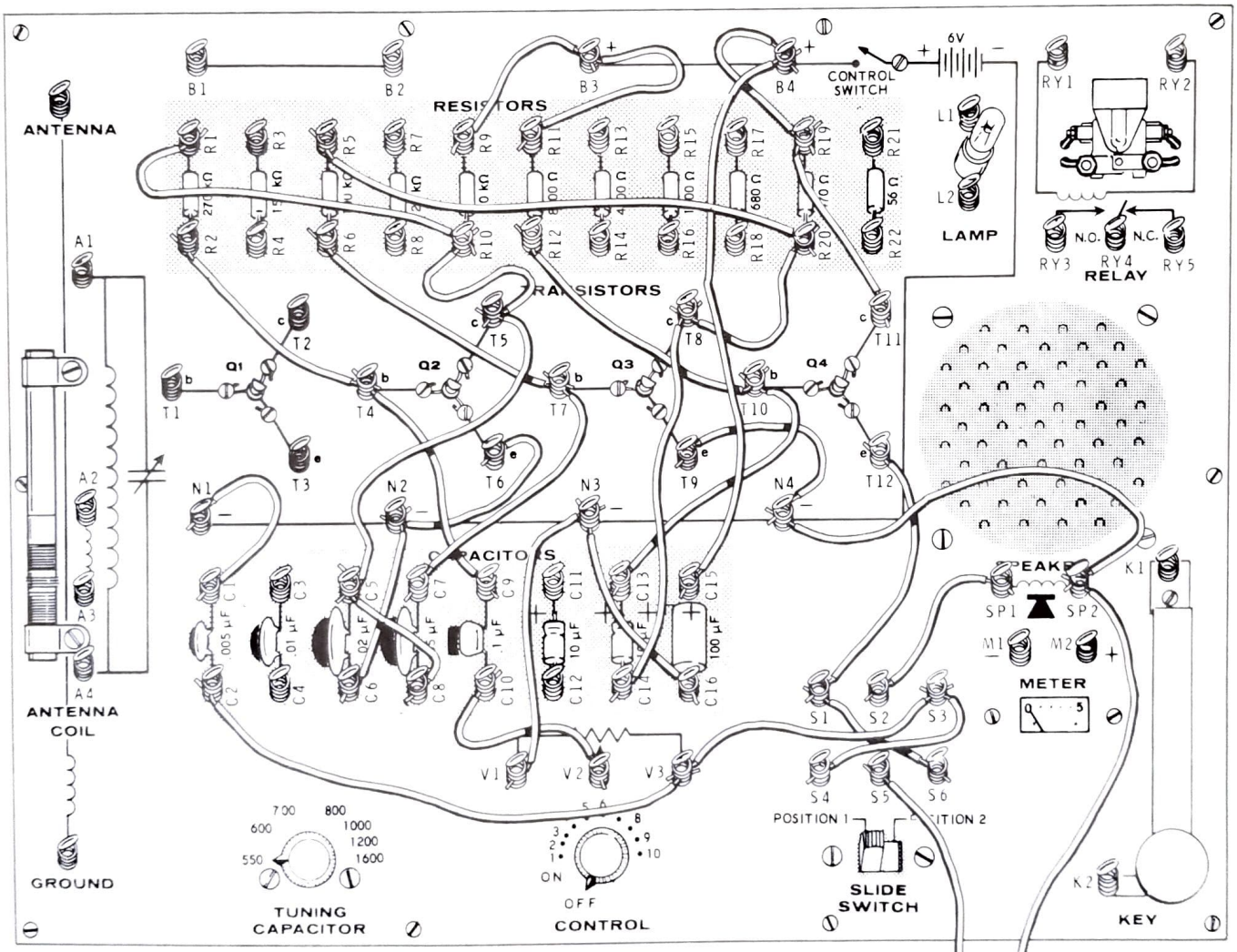
Place the Remote Station in another room, the farther away the better. Turn the Control clockwise. The Public Address Amplifier is now ready to use again.

EXPERIMENT 10

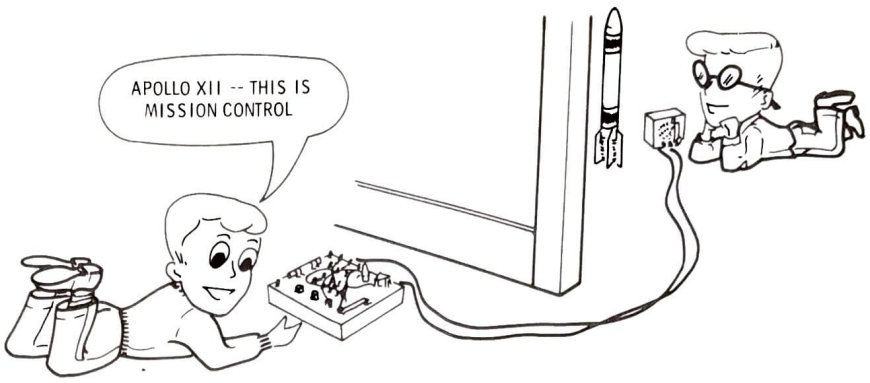
Intercom

problem

This Intercom will let you talk with another person in a distant room. The Workshop will be in one room and the Remote Station in the other room.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
FIFTEEN 3" BLACK	R9	B3	R11
	R10	T5	
	T6	N2	C6
	C5	C8	
	C10	V2	
	C1	N1	
	N4	T9	
	T8	R20	
	T11	R19	B4
	S1	S6	
	S2	SP1	
	S3	S4	
TEN 4" BROWN	R2	T4	C9
	R6	T7	C7
	R12	T10	C13
	C16	N3	V1
	V3	S3	
	S1	T12	
FOUR 6" RED	R1	R10	
	T5	C5	
	T8	C14	
	N4	SP2	
THREE 8" ORANGE	B4	C15	
	R5	R20	
	C2	V3	
25' WHITE	SP2	COM	REMOTE STATION
25' WHITE - BLUE	S5	SP3	



OPERATION

Place the Workshop in one room and the Remote Station in another room. Then have a friend at the Remote Station while you stay at the Workshop.

( ) Turn the CONTROL to position 8. Turn it further clockwise later if you want louder sound. NOTE: The CONTROL adjusts the volume for both units.

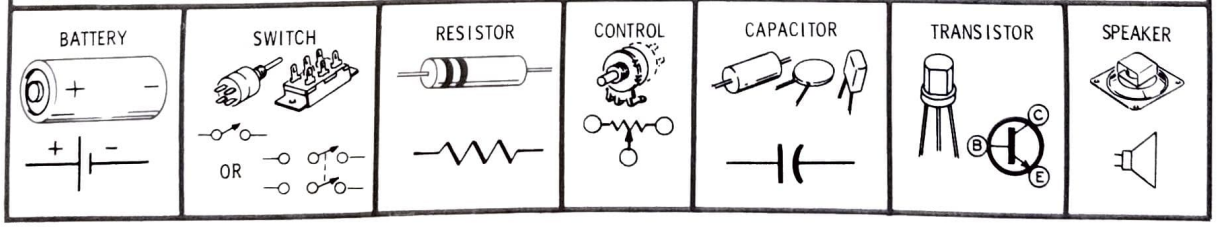
( ) Set the SLIDE SWITCH to position 2 and talk into the Speaker. Your friend should hear you at the Remote Station.

( ) Push the SLIDE SWITCH to position 1 and have your friend talk into the Remote Station. You should be able to hear him at the Workshop.

( ) Turn off the CONTROL when you complete the Experiment.

PARTS

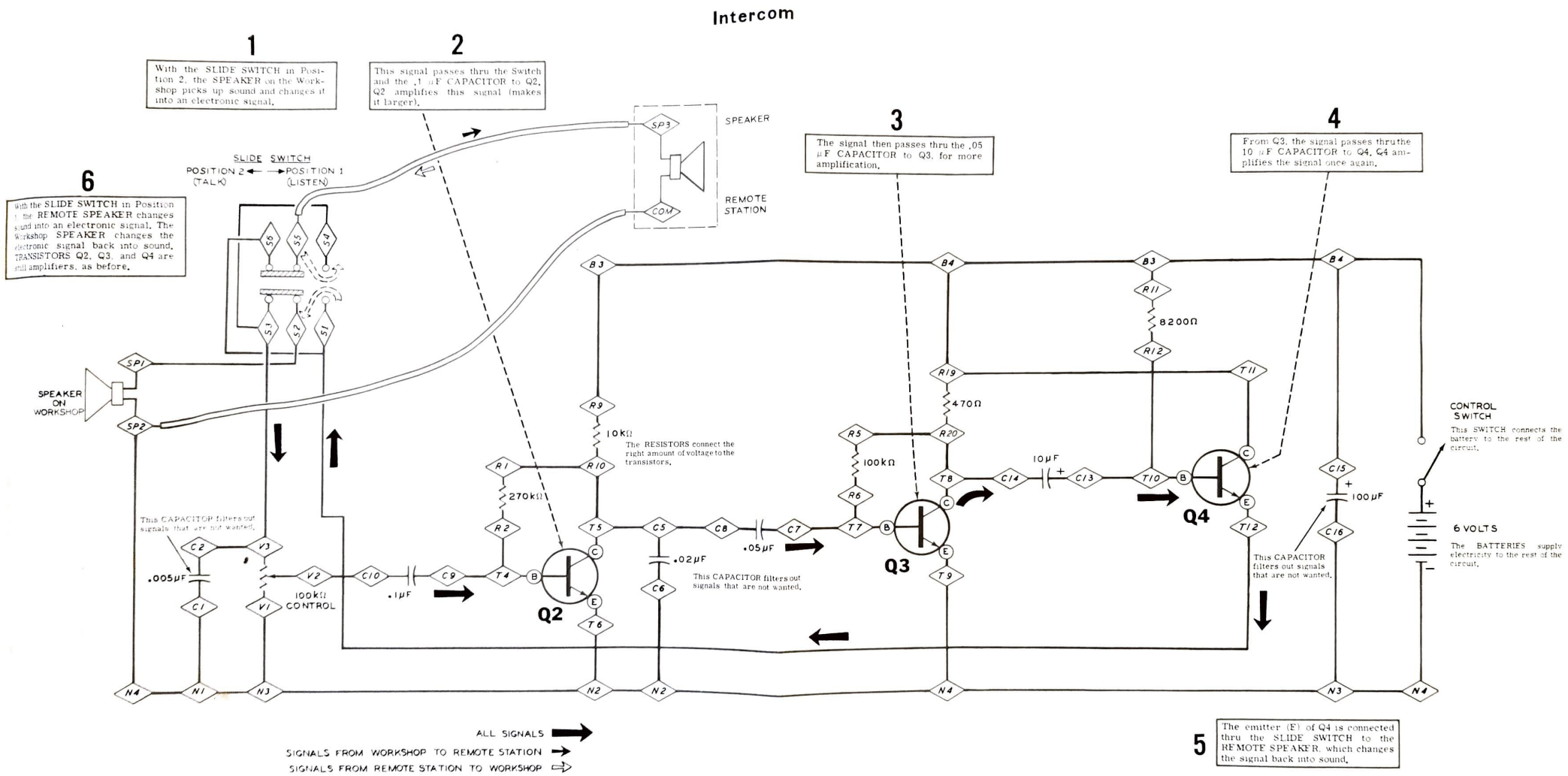
OLD PARTS



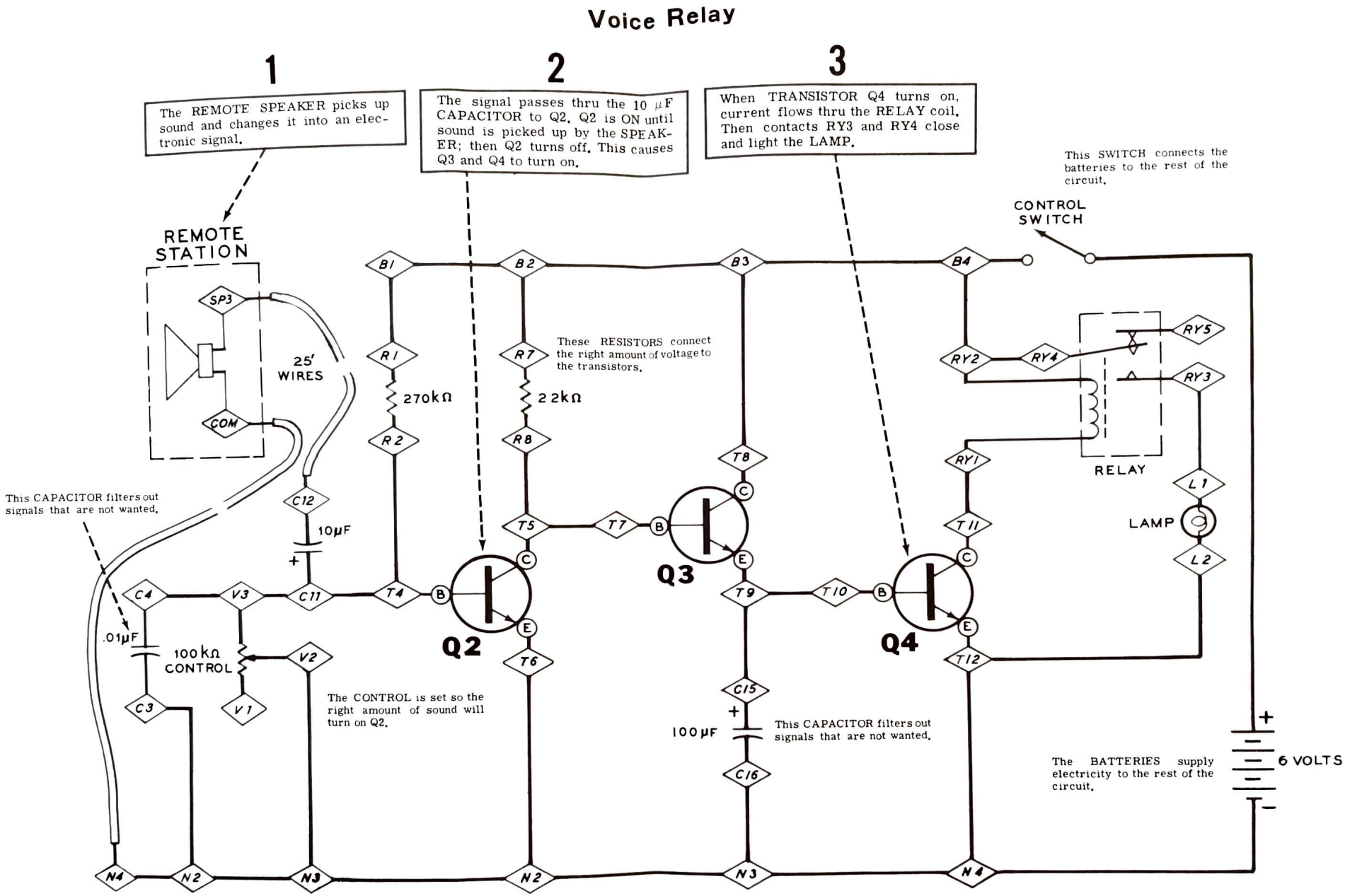
WHAT HAPPENS IN THE CIRCUIT

See the fold-out from this Page.

Intercom


1
With the SLIDE SWITCH in Position 2, the SPEAKER on the Workshop picks up sound and changes it into an electronic signal.
2
This signal passes thru the Switch and the .1 μF CAPACITOR to Q2. Q2 amplifies this signal (makes it larger).
3
The signal then passes thru the .05 μF CAPACITOR to Q3, for more amplification.
4
From Q3, the signal passes thru the 10 μF CAPACITOR to Q4. Q4 amplifies the signal once again.
5
The emitter (E) of Q4 is connected thru the SLIDE SWITCH to the REMOTE SPEAKER, which changes the signal back into sound.
6
With the SLIDE SWITCH in Position 1, the REMOTE SPEAKER changes sound into an electronic signal. The Workshop SPEAKER changes the electronic signal back into sound. TRANSISTORS Q2, Q3, and Q4 are still amplifiers, as before.
SLIDE SWITCH
POSITION 2 (TALK)
POSITION 1 (LISTEN)
SP3
SPEAKER
COM
REMOTE STATION
SP1
SP2
SPEAKER ON WORKSHOP
S6
S5
S4
S3
S2
S1
B3
B4
R11
8200Ω
R12
R19
T11
470Ω
R20
R9
10kΩ
The RESISTORS connect the right amount of voltage to the transistors.
R5
100kΩ
R6
R1
270kΩ
R10
T8
C14
10μF
C13
T10
Q4
C15
100μF
C16
T12
CONTROL SWITCH
This SWITCH connects the battery to the rest of the circuit.
6 VOLTS
The BATTERIES supply electricity to the rest of the circuit.
This CAPACITOR filters out signals that are not wanted.
C2
.005μF
C1
V3
V2
100kΩ CONTROL
V1
C10
.1μF
C9
R2
T4
Q2
T5
C5
.02μF
C6
T6
C8
.05μF
C7
T7
Q3
T9
This CAPACITOR filters out signals that are not wanted.
This CAPACITOR filters out signals that are not wanted.
N4
N1
N3
N2
N2
N4
N3
N4
ALL SIGNALS
SIGNALS FROM WORKSHOP TO REMOTE STATION
SIGNALS FROM REMOTE STATION TO WORKSHOP

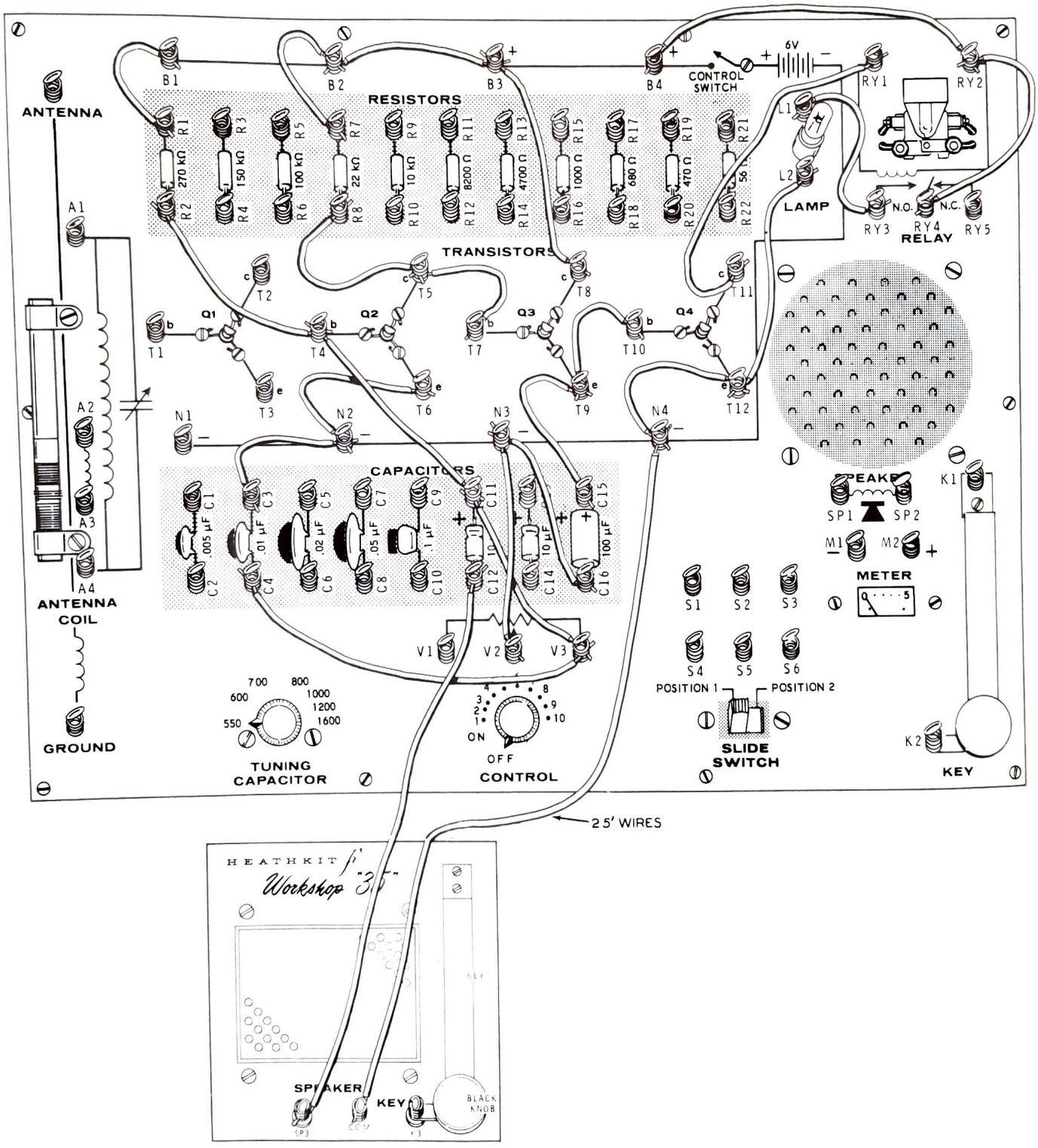
Voice Relay


1
The REMOTE SPEAKER picks up sound and changes it into an electronic signal.
2
The signal passes thru the 10 μF CAPACITOR to Q2. Q2 is ON until sound is picked up by the SPEAKER; then Q2 turns off. This causes Q3 and Q4 to turn on.
3
When TRANSISTOR Q4 turns on, current flows thru the RELAY coil. Then contacts RY3 and RY4 close and light the LAMP.
REMOTE STATION
SP3
COM
25' WIRES
This SWITCH connects the batteries to the rest of the circuit.
CONTROL SWITCH
B1
B2
B3
B4
R1
270kΩ
R2
R7
22kΩ
R8
These RESISTORS connect the right amount of voltage to the transistors.
RY5
RY2
RY4
RY3
RELAY
RY1
L1
LAMP
L2
T8
T11
T5
T7
T9
T10
T12
T6
Q2
Q3
Q4
C12
10μF
This CAPACITOR filters out signals that are not wanted.
C4
V3
C11
T4
.01μF
100kΩ CONTROL
V2
V1
C3
The CONTROL is set so the right amount of sound will turn on Q2.
C15
100μF
C16
This CAPACITOR filters out signals that are not wanted.
The BATTERIES supply electricity to the rest of the circuit.
6 VOLTS
N4
N2
N3
N2
N3
N4

EXPERIMENT 11

Voice Relay

The speaker is again used as a microphone in this Voice Relay circuit. When you talk into the speaker, this circuit makes the relay operate and turns on the lamp. Circuits like this are often used in radio transmitters to automatically turn on the transmitter when the operator starts to talk.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
ELEVEN 3" BLACK	B1	R1	
	B3	B2	R7
	R8	T5	T7
	T6	N2	C3
	T10	T9	C15
	T12	N4	
	L1	RY3	
EIGHT 4" BROWN	R2	T4	C11
	C11	V3	
	V2	N3	C16
	T12	L2	
	RY2	RY4	
	B3	T8	
THREE 6" RED	B4	RY2	
	RY1	T11	
	C4	V3	
25' WHITE	N4	COM	REMOTE
25' WHITE - BLUE	C12	SP3	STATION

OPERATION

NOTE: The Lamp may come on for an instant when the CONTROL is first turned on.

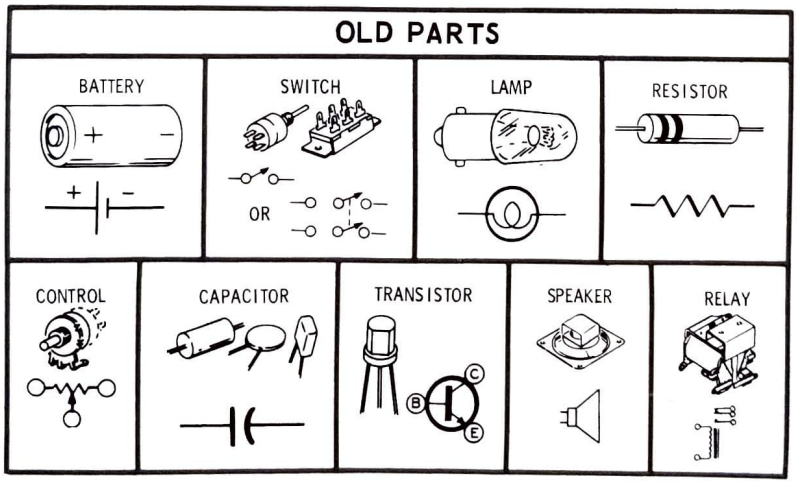
( ) Turn the CONTROL slowly clockwise until the Lamp lights and stays lit.

( ) Turn the CONTROL counterclockwise just to the point where the Lamp turns off.

( ) Speak directly into the Remote Station speaker at close range; the Lamp should light. When you stop speaking the Lamp should turn off. If the Lamp stays lit, turn the CONTROL just barely counter-clockwise.

( ) Turn off the CONTROL when you complete the Experiment.

PARTS



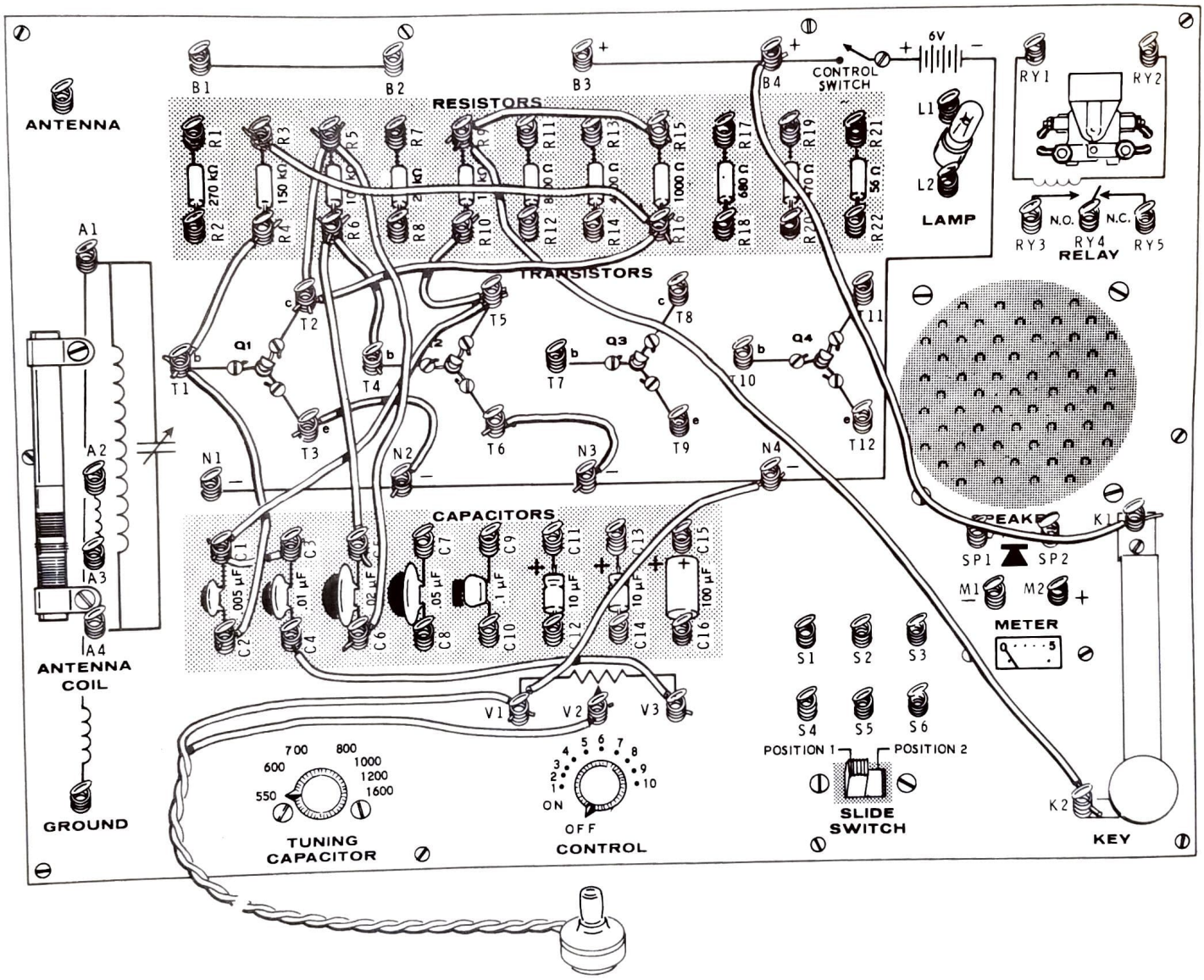
WHAT HAPPENS IN THE CIRCUIT

See the fold-out from Page 68.

EXPERIMENT 12

Earphone Code Oscillator

A circuit that makes its own signal is called an "oscillator". When you press the KEY, this oscillator will produce a tone you can hear in the Earphone. You can use the tone to practice and learn Morse Code. This oscillator also has a volume control so you can adjust the loudness.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
SEVEN 3" BLACK	R5	T2	
	R6	T4	
	R9	R15	
	R10	T5	
	T6	N3	
	C1	C3	
	T3	N2	
ONE 4" BROWN	R4	T1	
SIX 6" RED	C4	V3	
	R16	T2	
	T5	C1	
	V1	N4	
	T1	C2	
	C5	R6	
TWO 8" ORANGE	R3	R16	
	C6	R5	
ONE 10" YELLOW	K1	B4	
ONE 14" BROWN	K2	R9	
EARPHONE	V1	V2	

OPERATION

( ) Turn the CONTROL clockwise to position 4.

( ) Put the Earphone in your ear and press the KEY. The oscillator should make a tone that sounds like a musical note.

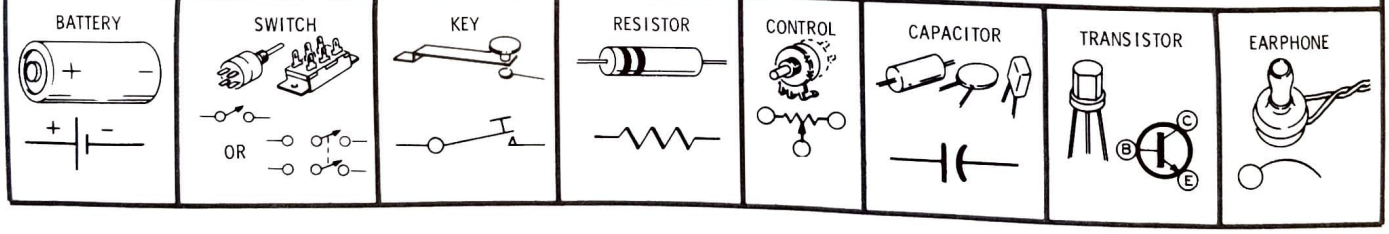
Your Earphone Code Oscillator is now ready to use. Refer to the Morse Code on Page 162.

You will learn the code best if you practice with someone else, sending signals to them and letting them send signals to you. It will also help if you try to learn just a few letters at a time. You could begin, for example, with simple letters, like E, I, S, and H, and T, M, and O.

( ) Turn off the CONTROL when you complete the Experiment.

PARTS

OLD PARTS



WHAT HAPPENS IN THE CIRCUIT

See the fold-out from this Page.

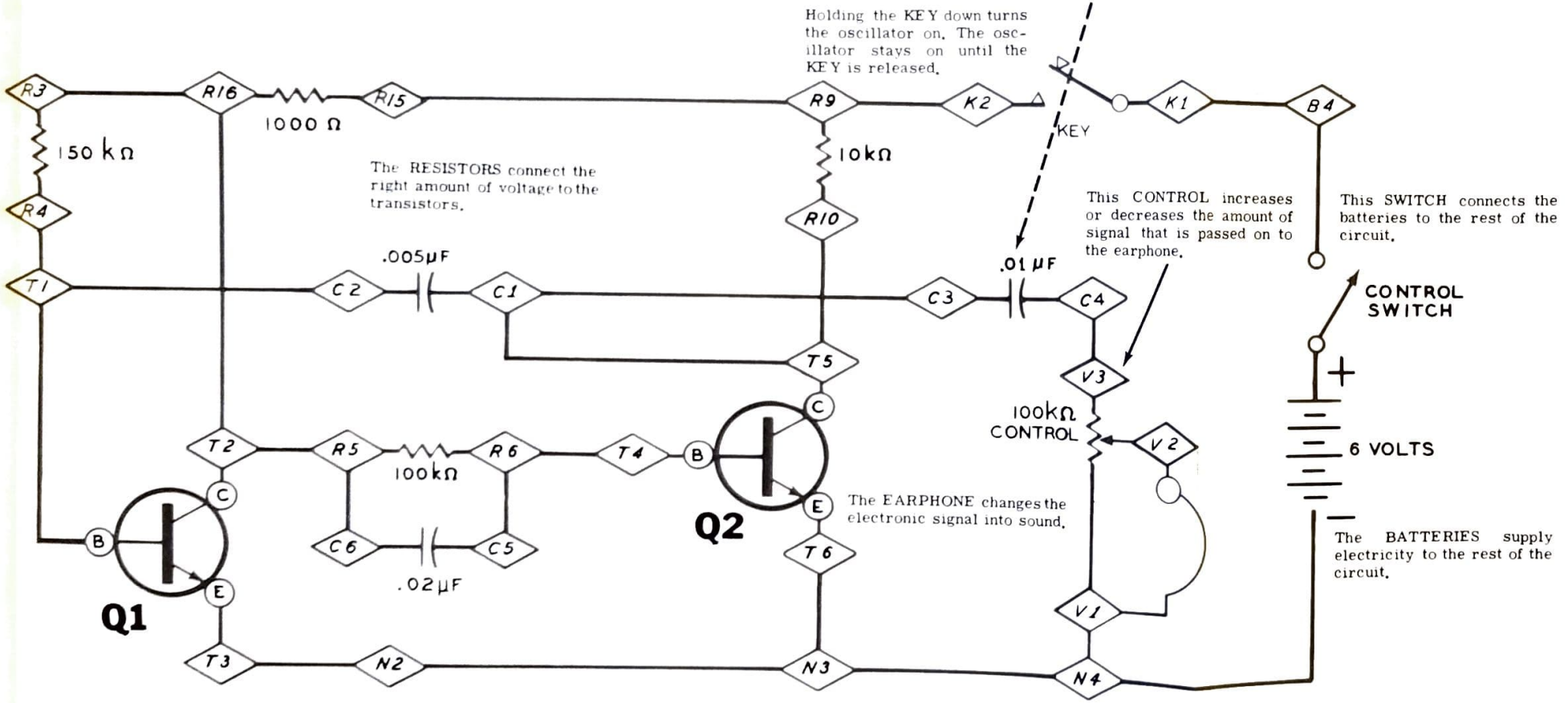
Earphone Code Oscillator

1

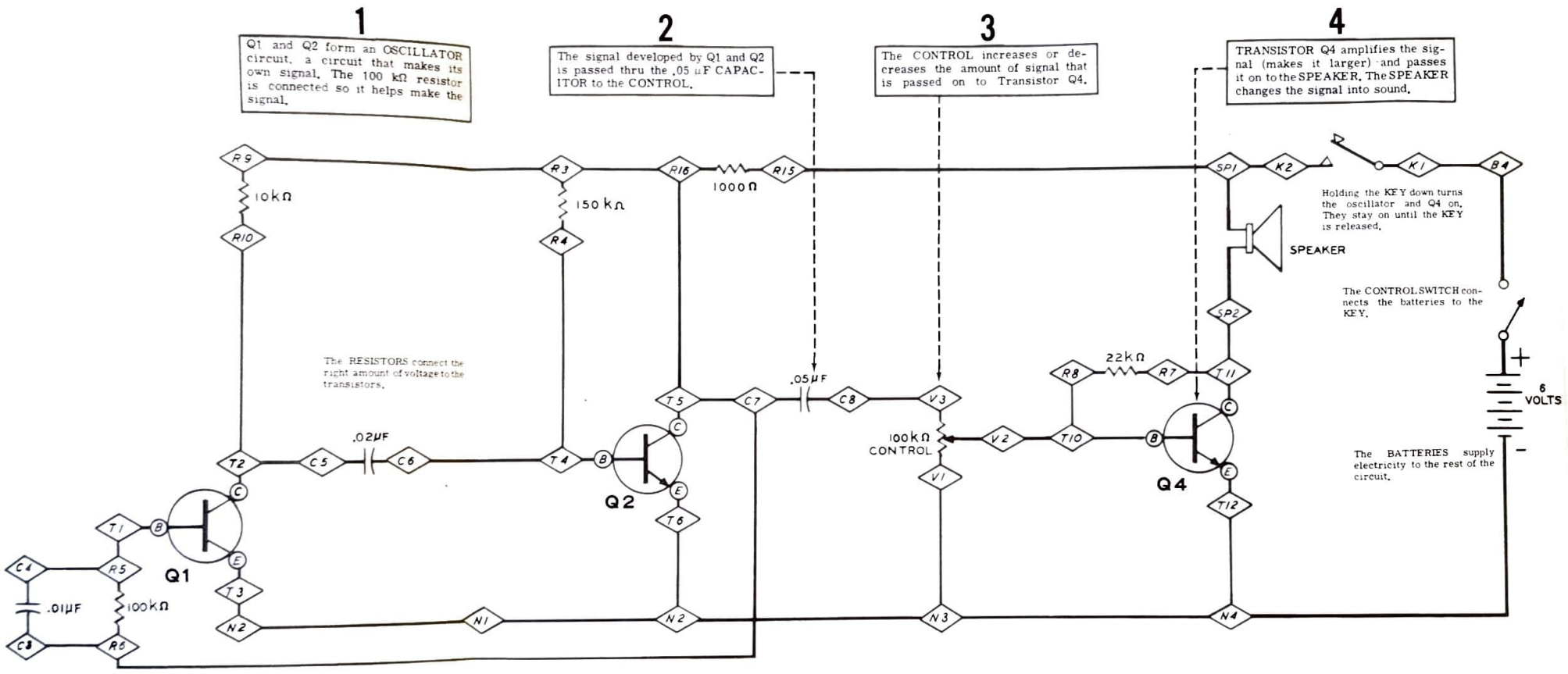
Q1 and Q2 form an OSCILLATOR circuit, a circuit that makes its own signal. The .005 μF CAPACITOR helps make the signal.

2

The signal developed by Q1 and Q2 is passed thru the .01 μF CAPACITOR to the CONTROL.



Loudspeaker Code Oscillator

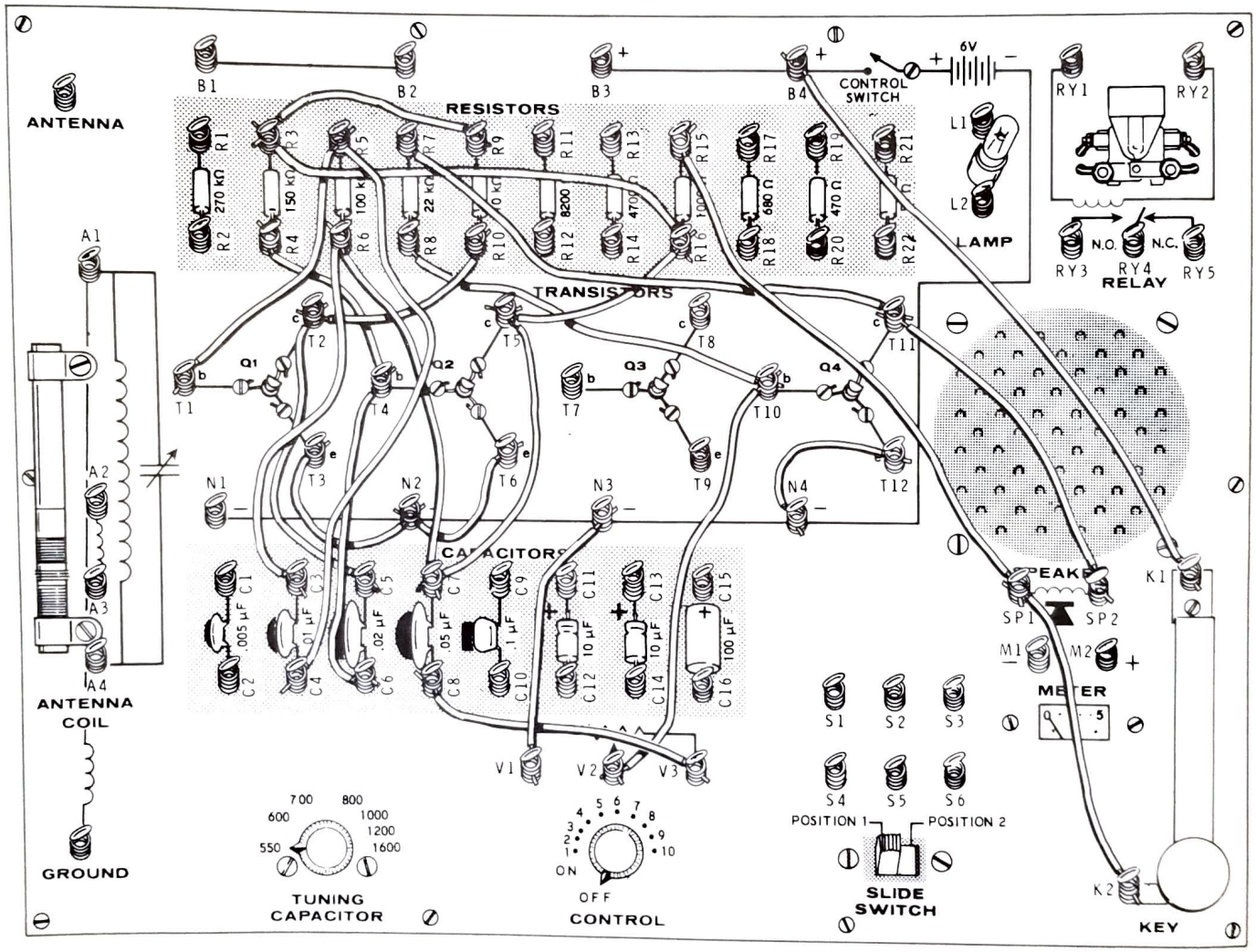


EXPERIMENT 13

Loudspeaker Code Oscillator

In this Experiment you will build a Loudspeaker Oscillator that will let you practice Morse Code and hear it from the speaker. This oscillator also has a Volume control so you can adjust the loudness.

This Experiment uses the same type of circuit that was used in the last Experiment, except that an amplifier is added. (See the second Theory Note on Page 60.) The amplifier makes the signal large enough to work the speaker.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
SEVEN 3" BLACK	T4	R4	
	T5	R16	
	T3	N2	T6
	T2	R10	
	T12	N4	
	R3	R9	
FOUR 4" BROWN	T1	R5	
	T2	C5	
	T5	C7	
	V1	N3	
EIGHT 6" RED	C6	T4	
	R8	T10	V2
	C8	V3	
	T11	SP2	
	SP1	K2	
	R6	C7	
	C3	R6	
FOUR 8" ORANGE	R15	SP1	
	R7	T11	
	C4	R5	
	R3	R16	
ONE 10" YELLOW	B4	K1	

OPERATION

( ) Turn the CONTROL to position 5.

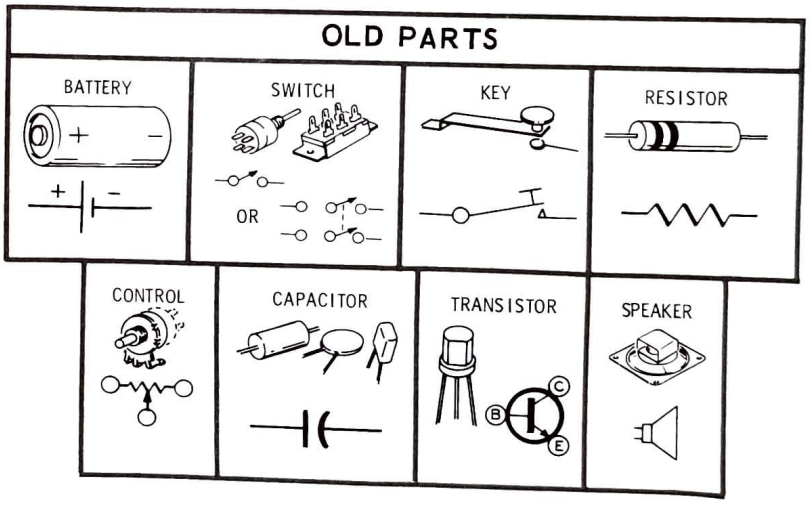
( ) Press the KEY. The oscillator should make a tone that sounds like a musical note.

( ) Adjust the CONTROL for a comfortable listening level.

Your Loudspeaker Code Oscillator is now ready to use. Refer to the Morse Code on Page 162 and to the note about learning the Code in the previous Experiment.

( ) Turn off the CONTROL when you complete the Experiment.

PARTS



WHAT HAPPENS IN THE CIRCUIT

See the fold-out from Page 72.

THINGS TO DO AFTER THE EXPERIMENT

( ) Connect a 25' wire from K1 to COM on the Remote Station.

( ) Connect a 25' wire from K2 to K3 on the Remote Station.

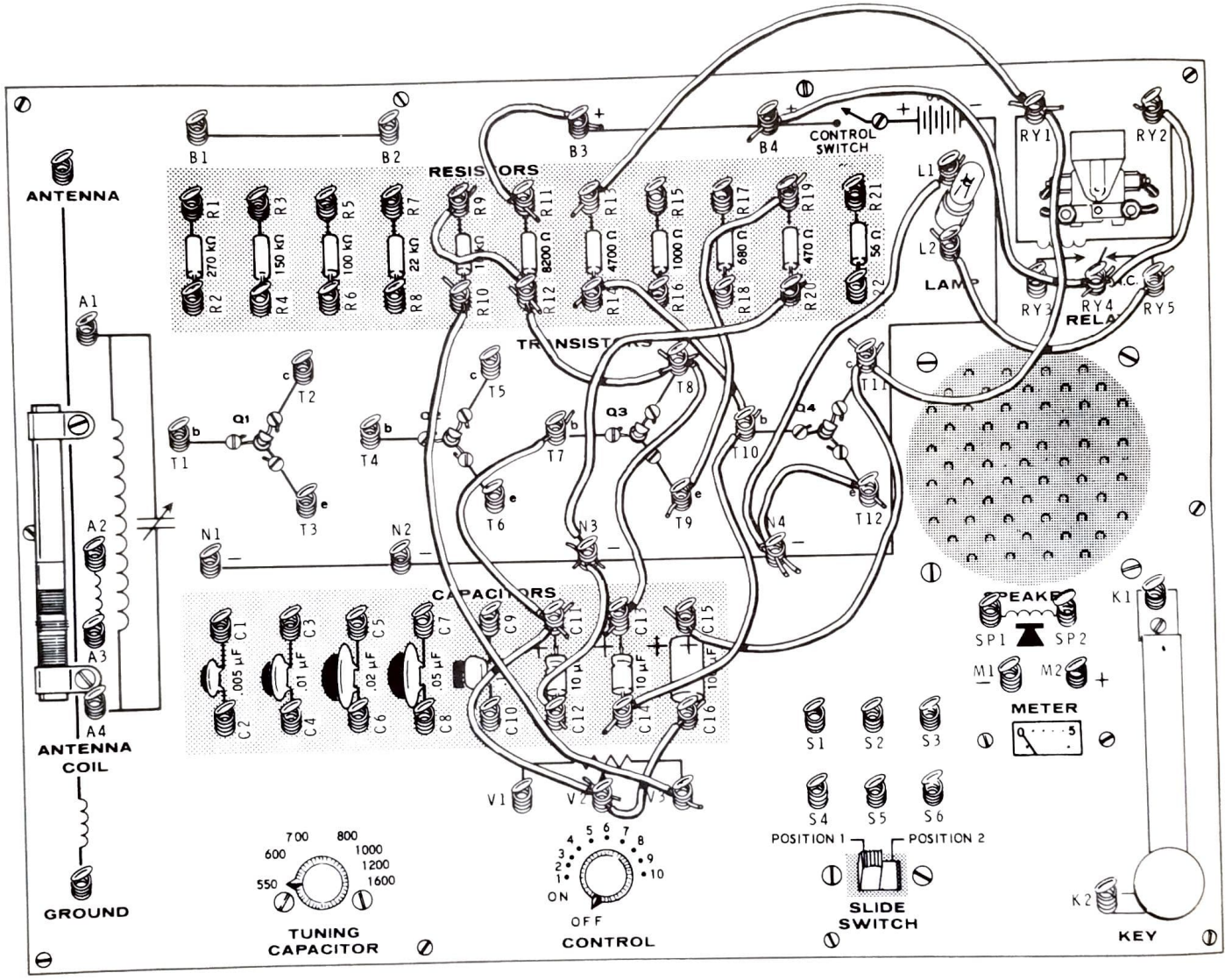
Now two people can send code at the same time.

EXPERIMENT 14

Electronic Flasher

This Electronic Flasher will turn the Lamp on and off automatically. You should be able to change the speed by turning the Control.

Problem



WIRING CHART			
USE	FROM	TO	
		FROM	TO
SEVEN 3" BLACK	B3	R11	
	R9	R12	T8
	T12	N4	
	C12	N3	
	C16	V2	
	RY4	RY2	
FOUR 4" BROWN	T7	C11	V2
	L2	RY5	
	R14	T10	
EIGHT 6" RED	RY4	B4	
	RY1	T11	C15
	R19	T9	
	C13	T8	
	C14	T10	
	R20	N3	
	L1	N4	
TWO 8" ORANGE	R10	V3	
	R13	RY1	

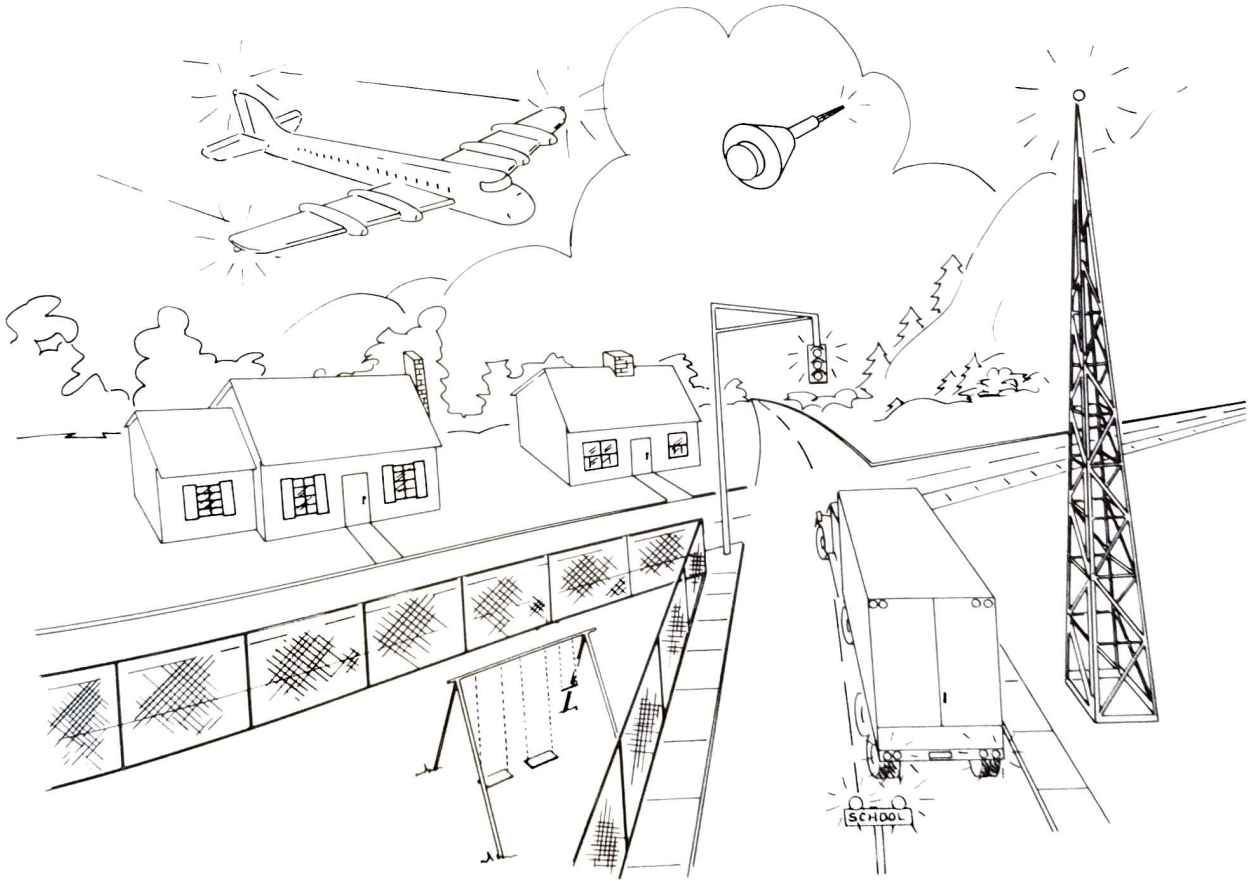
OPERATION

( ) Turn the CONTROL clockwise until the switch clicks ON. The Lamp should flash on and off slowly.

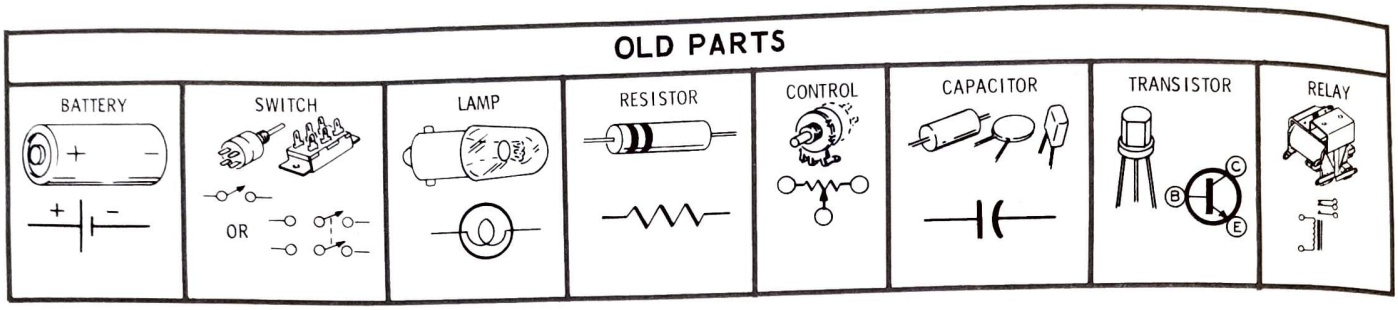
( ) Turn the CONTROL further clockwise; the flasher will flash at a faster rate. If you turn the CONTROL back the other way, it will slow down again.

( ) Turn off the CONTROL when you complete the Experiment.

Flashers are used as warning devices, to get our attention. Some are electronic like this, others are turned on and off by a motor and switch. Still others are turned on and off by the heating and cooling of metal. With an electronic flasher, the flashing speed is easily controlled and the parts will last for a long time.



PARTS



THINGS TO DO AFTER THE EXPERIMENT

You may use the flasher as a warning device by placing red plastic over the Lamp. You can also place other plastic pieces over the Lamp to produce different effects.

You may wish to have the flasher on longer than it is off. To do this, disconnect the wire from RY5 and connect it to RY3.

WHAT HAPPENS IN THE CIRCUIT

Electronic Flasher

1

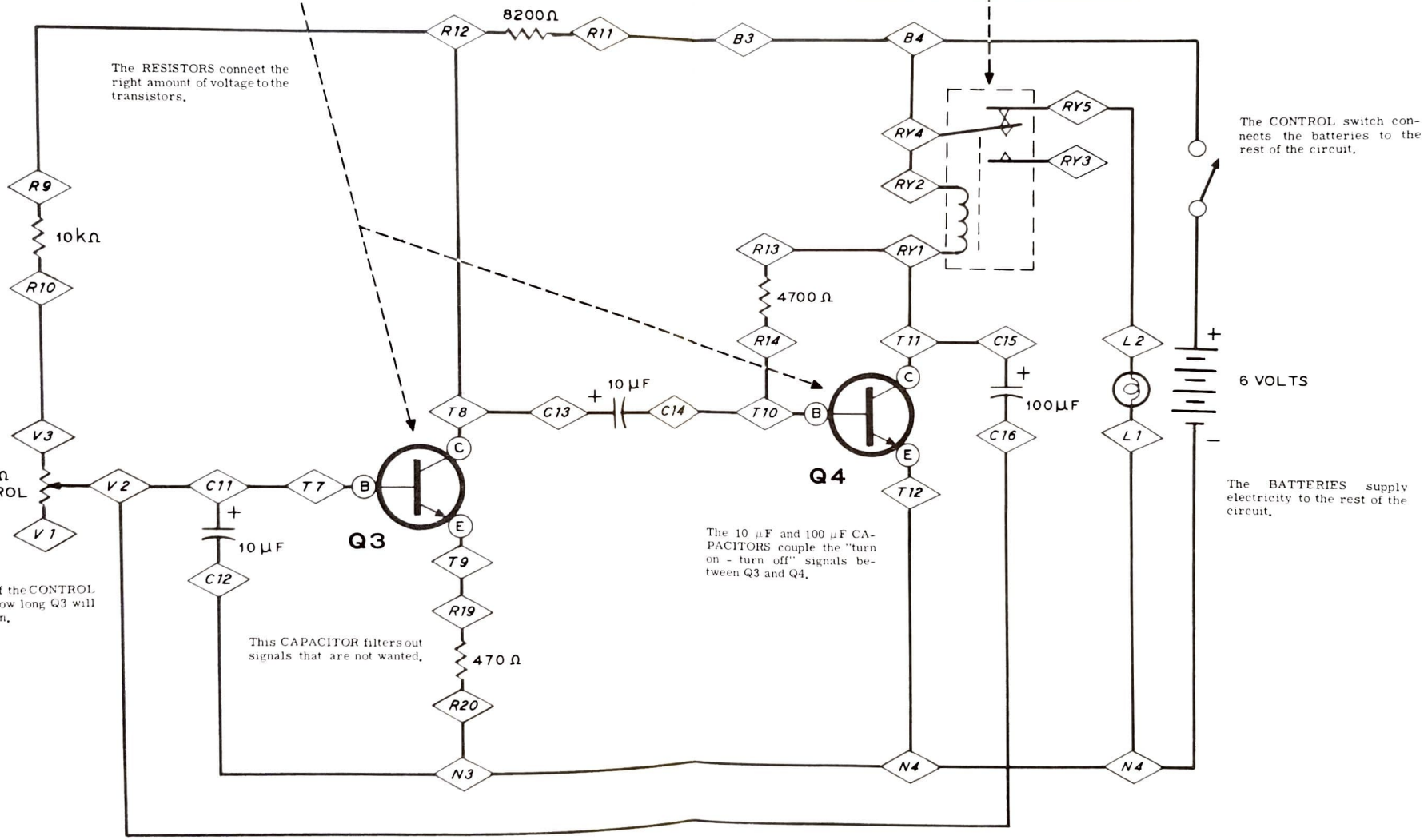
Q3 and Q4 form a MULTIVIBRATOR circuit, a circuit that makes its own signal.

2

This circuit makes a signal by Q3 and Q4 turning each other on and off. When Q3 is on, Q4 is off. When Q3 is off, Q4 is on.

3

Each time Q4 turns on, enough current passes thru the coil of the RELAY to open contacts RY4 and RY5. This turns the LAMP off until Q4 turns off again.



Experimental Multivibrator

1

Q3 and Q4 form a MULTIVIBRATOR circuit, a circuit that makes its own signal.

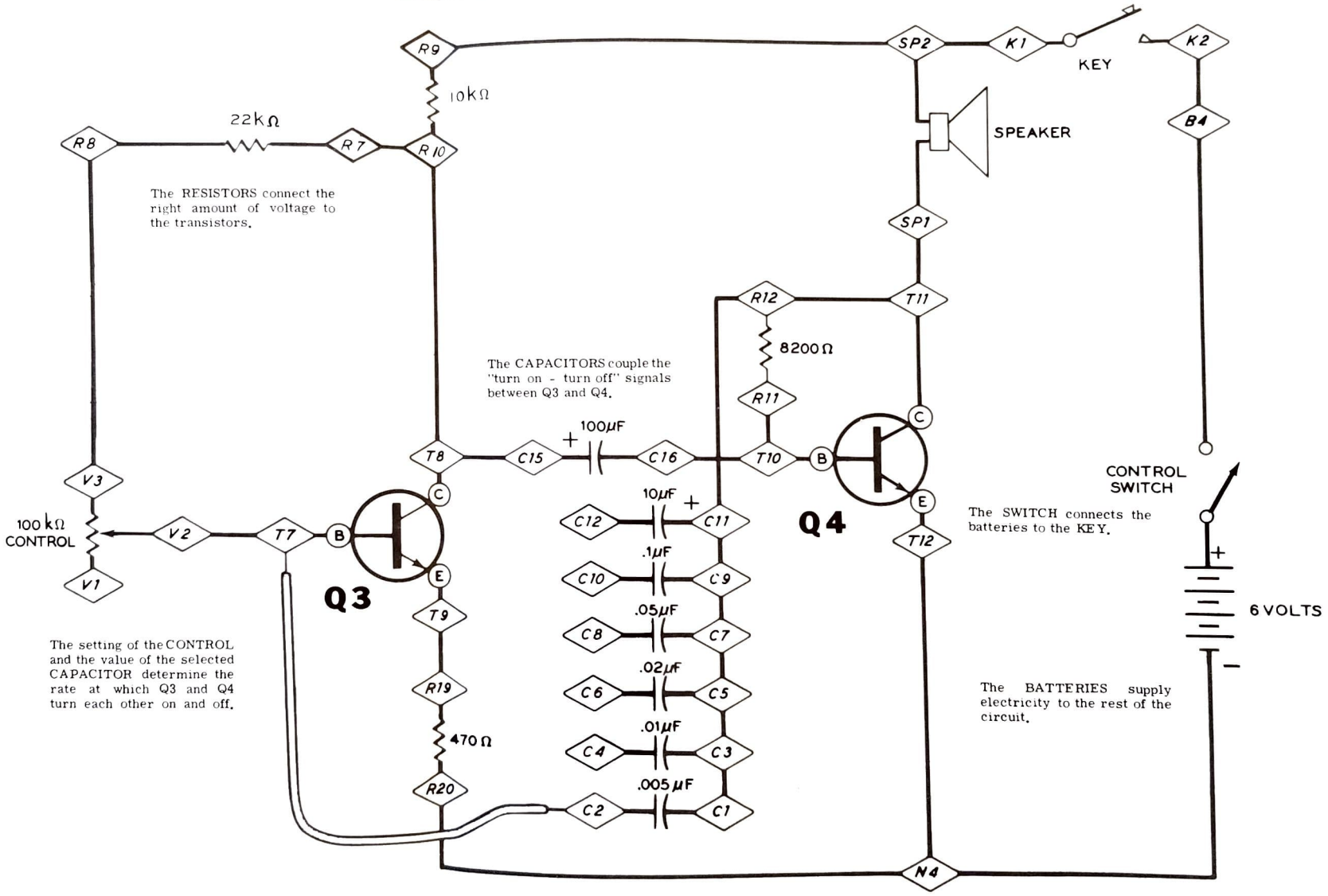
2

This circuit makes a signal by Q3 and Q4 turning each other on and off. When Q3 is on, Q4 is off. When Q3 is off, Q4 is on.

3

The turning on and off of Q3 and Q4 produces an electronic signal which the speaker changes into a sound.

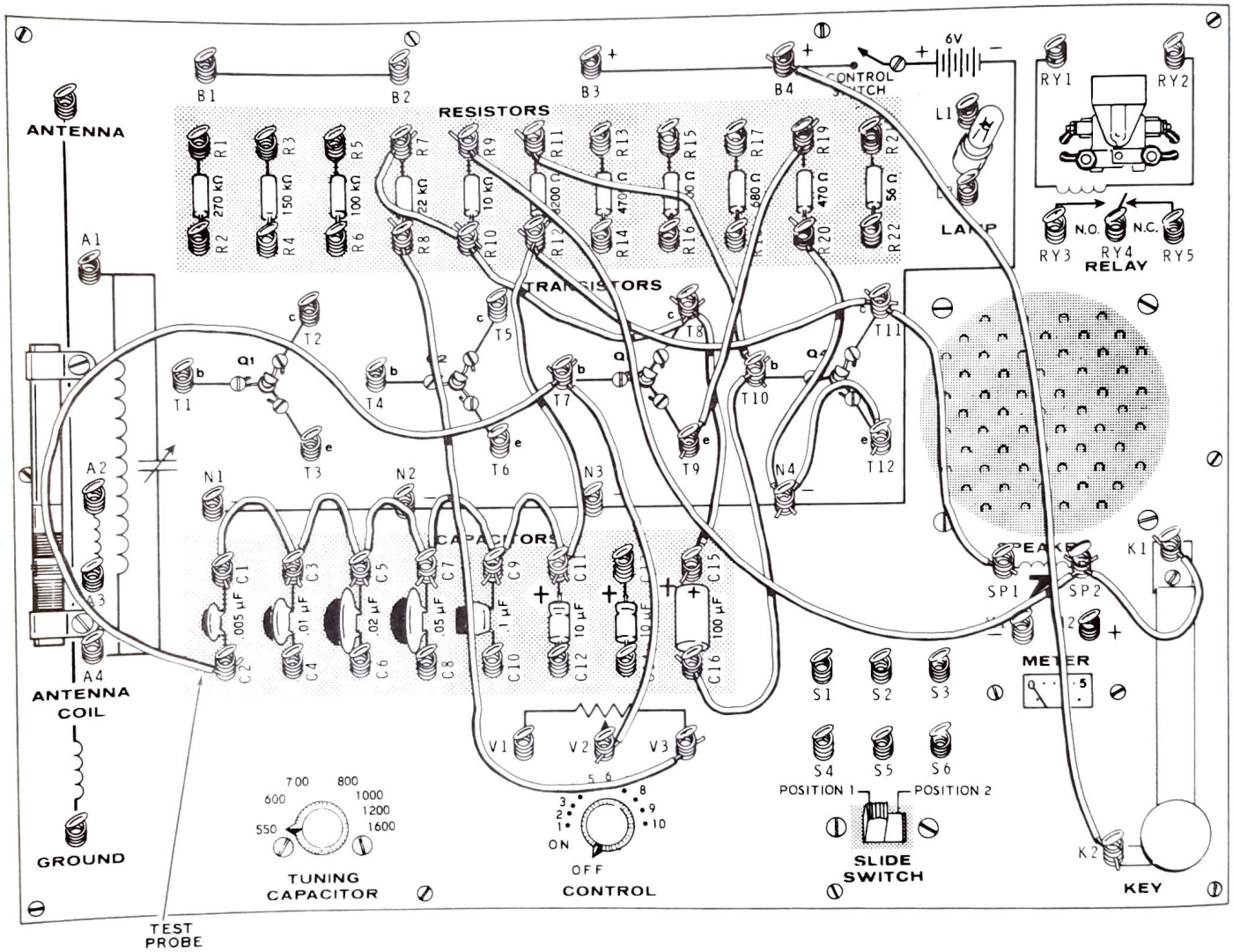
Holding the KEY down turns the Multivibrator on by connecting the batteries to the rest of the circuit.



EXPERIMENT 15

Experimental Multivibrator

Testing devices like this Experimental Multivibrator are used quite often by electronic engineers and technicians to make signals. These signals are then used to test many kinds of electronic equipment (like radios, TV sets, Transmitters, etc.).



WIRING CHART			
USE	FROM	TO	
		FROM	TO
EIGHT 8" BLACK	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	
	[illegible]	[illegible]	
	[illegible]	[illegible]	
	[illegible]	[illegible]	
THREE 3" BROWN	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	
SEVEN 4" RED	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	
	[illegible]	[illegible]	
	[illegible]	[illegible]	
ONE 10" YELLOW	[illegible]	[illegible]	
TWO 12" BLACK	[illegible]	[illegible]	
	[illegible]	[illegible]	
TEST PROBE			
ONE 14" BROWN	[illegible]	[illegible]	

OPERATION

( ) Turn the CONTROL clockwise until the switch clicks ON.

( ) Press the KEY. The oscillator will make a signal that you will hear in the Speaker. Its tone will go up as you hold down the KEY.

( ) Push the KEY and turn the CONTROL clockwise, the tone (pitch) will go even higher.

( ) Move the Test Probe from C2 to C4 and press the KEY again. The tone (pitch) will sound lower than before.

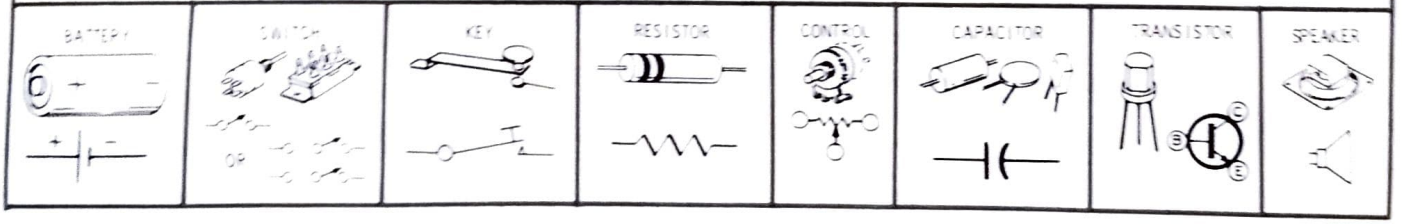
( ) Move the Test Probe to each of the following connections: C6, C8, C10. Press the KEY each time you move the Test Probe. The tone will change each time you move the Probe because the capacitors are different electrical sizes.

( ) Move the Test Probe to C12. Now the tone is so low that you only hear it as a popping sound in the Speaker. Notice that when you turn the CONTROL, the popping noise changes speed.

( ) Turn off the CONTROL when you complete the Experiment.

PARTS

OLD PARTS



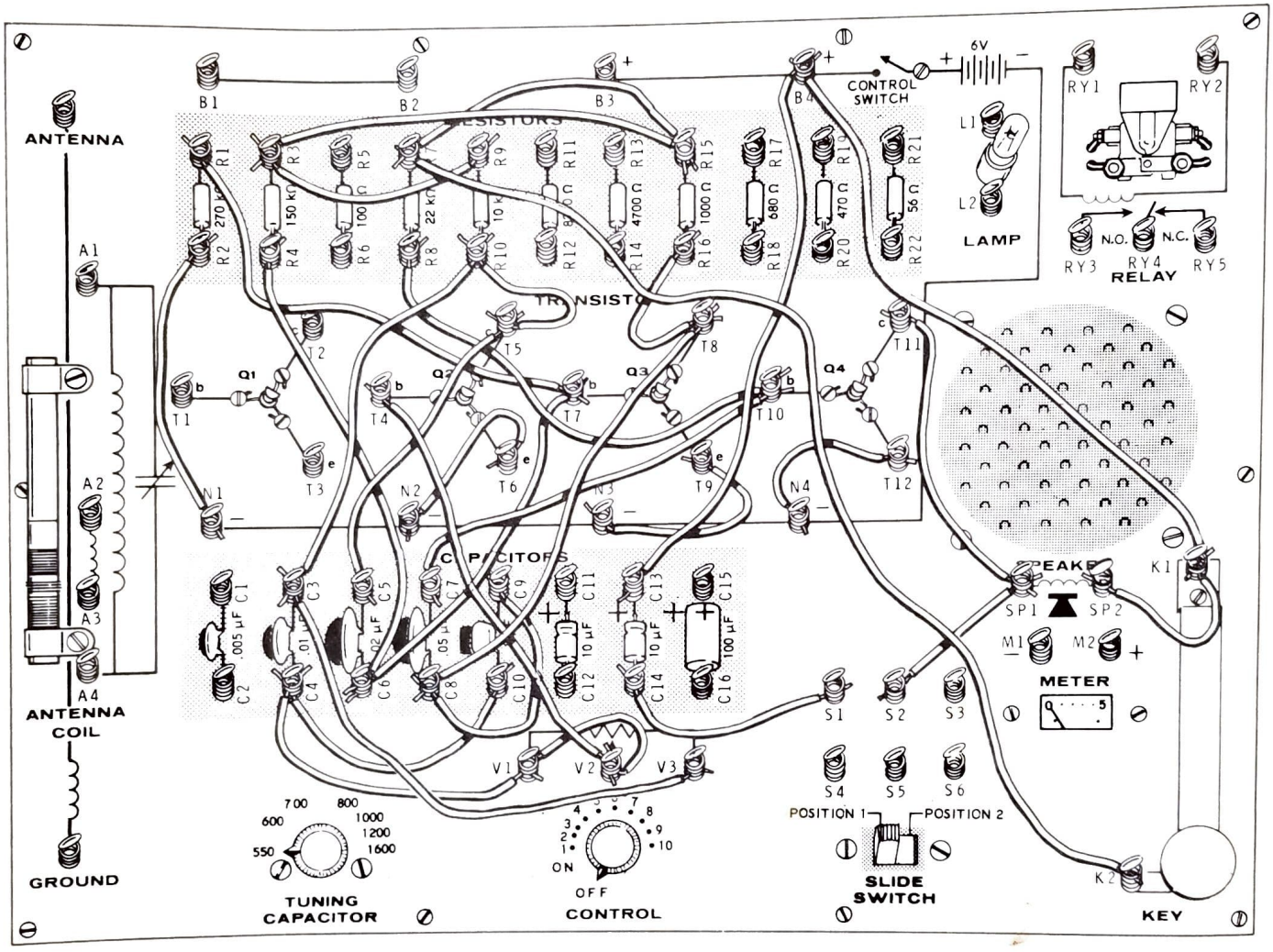
WHAT HAPPENS IN THE CIRCUIT

See the fold-out from Page 78.

EXPERIMENT 16

Electronic Organ

In this Experiment you will build a very simple Electronic Organ. You will even play a tune. This will show you how tones are made in electronic organs. In a large organ, each key on the keyboard turns on a circuit like this one.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
ELEVEN 3" BLACK	R3	R9	
	R10	T5	
	R16	T8	
	T6	N2	
	T9	N3	
	T12	N4	
	C4	C10	
	C9	C8	
	V1	V2	
	K1	SP2	
	S2	SP1	
FOUR 4" BROWN	R2	N1	
	R7	R15	
	C4	V1	
	C14	S1	
TEN 6" RED	R1	T7	C6
	R4	C6	
	R3	R15	
	R8	T10	C7
	R10	C3	V3
	T5	C5	
	T11	SP1	
THREE 8" ORANGE	T4	V2	
	C8	T8	
	B4	C13	
ONE 10" YELLOW	B4	K1	
ONE 14" BROWN	R7	K2	

OPERATION

( ) Place the SLIDE SWITCH in Position 1.

( ) Turn the CONTROL to position 1 and press the KEY. You should hear a tone from the speaker.

The following numbers make a simple tune ("Yankee Doodle") you can play on this organ circuit. Turn the CONTROL to each number, one at a time. Then press and release the key. You may also be able to make up some tunes of your own.

5 - 5 - 6 - 7 - 5 - 7 - 6

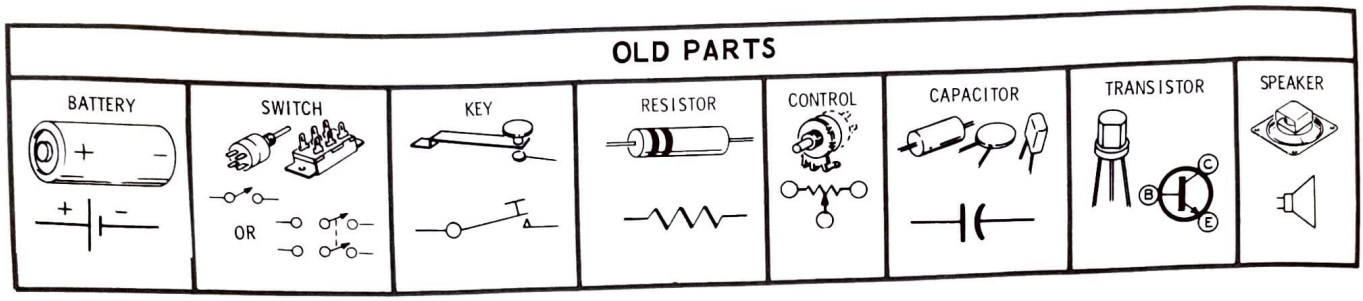
5 - 5 - 6 - 7 - 5 - 4-1/2

5 - 5 - 6 - 7 - 7-1/2 - 7 - 6

5 - 4-1/2 - 1 - 3 - 4-1/2 - 5 - 5

( ) Turn off the CONTROL when you complete the Experiment.

PARTS



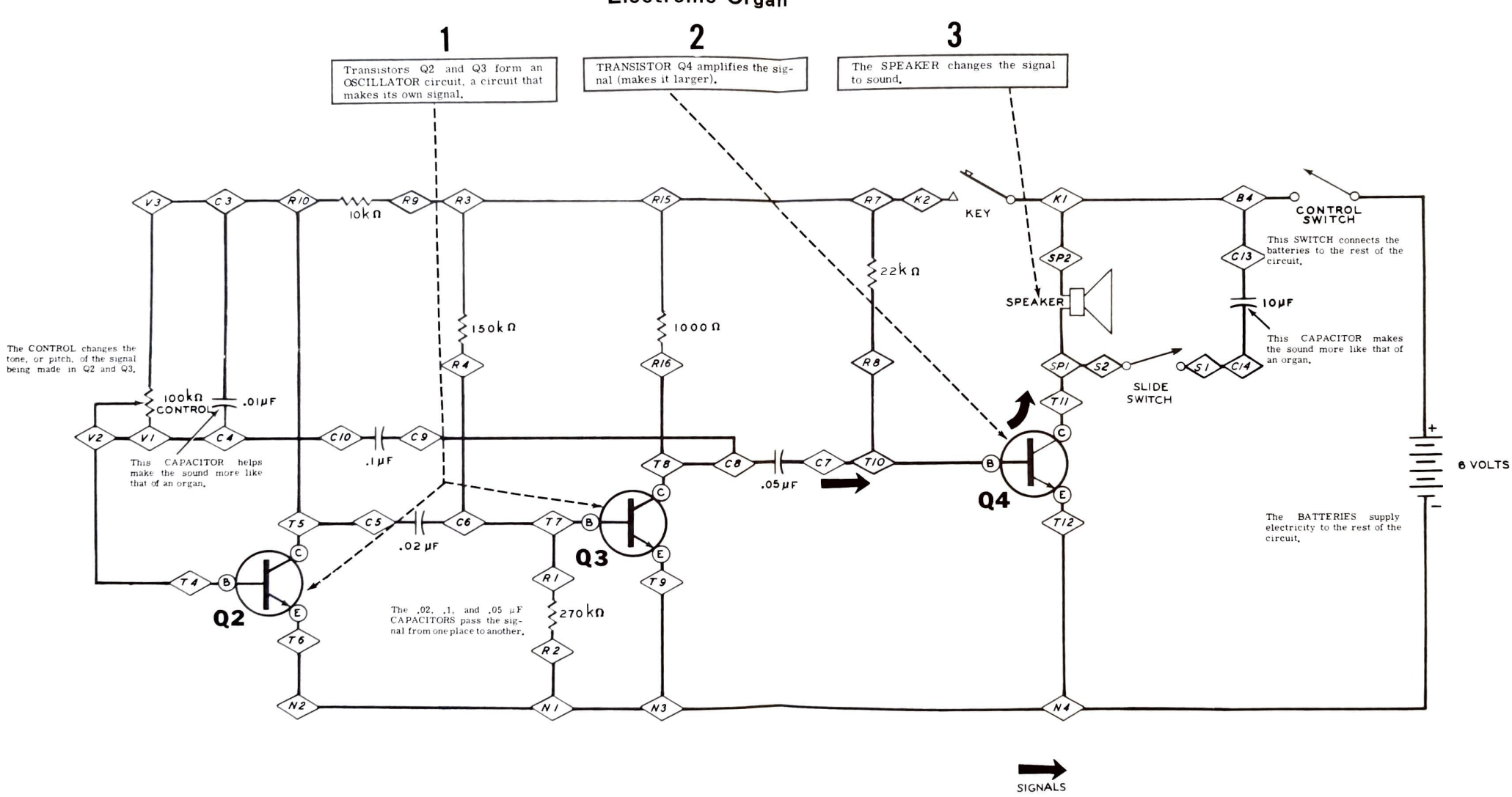
THINGS TO DO AFTER THE EXPERIMENT

The 10 μF capacitor gives "character" to the tones this organ circuit makes. In a large organ, a tone circuit could be connected where this capacitor is. One tone circuit might make the tone sound like it came from a violin, and another could make it sound like a tone from a trumpet.

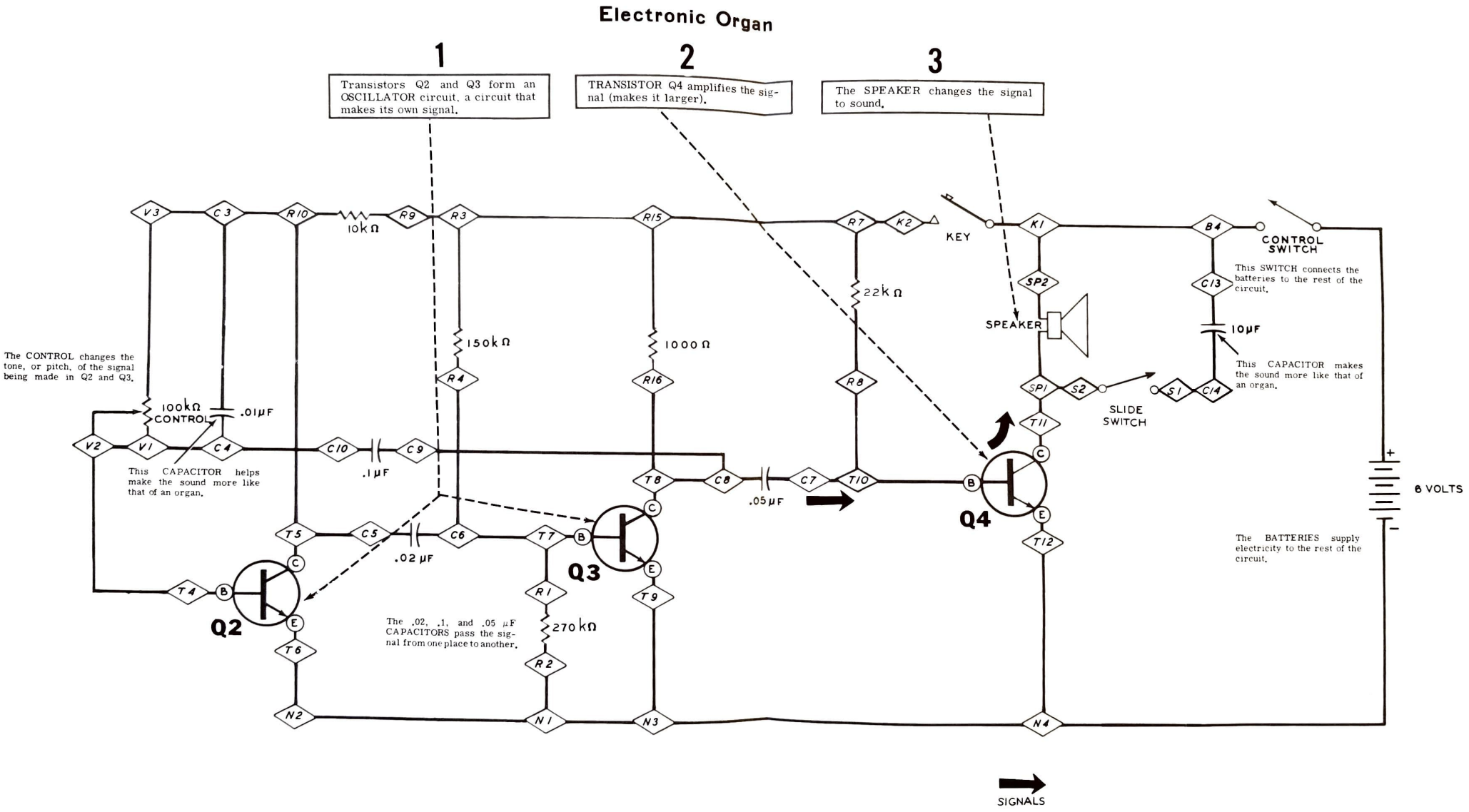
Push the SLIDE SWITCH from Position 1 to Position 2. Note how this makes the character of the tone change.

WHAT HAPPENS IN THE CIRCUIT

Electronic Organ



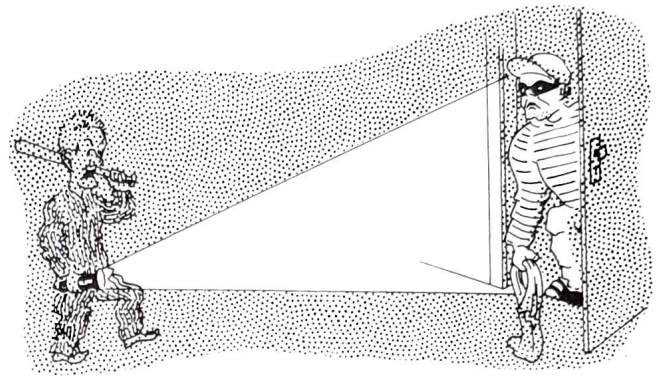
WHAT HAPPENS IN THE CIRCUIT

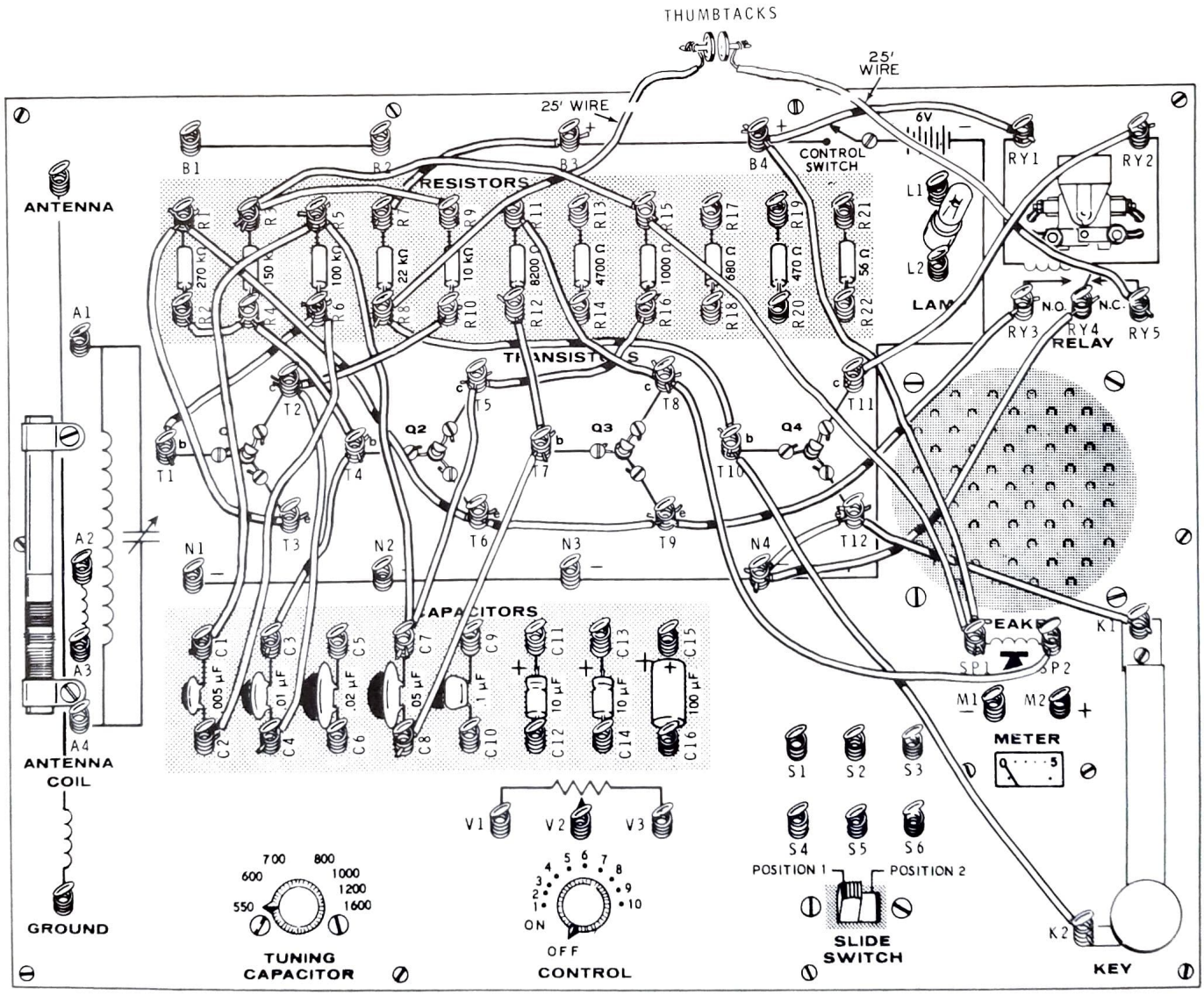


EXPERIMENT 17

Burglar Alarm

This Burglar Alarm can be connected to a door or window. A loud tone will then be sounded if the door or window is opened.





WIRING CHART			
USE	FROM	TO	
		FROM	TO
NINE 3" BLACK	R3	R9	
	T1	R6	
	T2	R10	
	T9	T6	
	T5	R16	
	R12	T7	
	N4	T12	
	T4	R4	R2
FIVE 4" BROWN	C3	T4	
	B4	RY1	
	T5	C7	
	R11	T8	
	R7	B3	
THIRTEEN 6" RED	RY2	T11	
	R8	T10	
	C7	R5	
	RY3	T9	
	T2	C4	
	C8	T7	
	R3	R15	
	T6	R1	T3
	K1	T12	
	RY4	N4	
	C1	R5	
	C2	R6	
THREE 8" ORANGE	R15	SP1	B4
	T8	SP2	
ONE 10" YELLOW	T10	K2	
25' WHITE	R8	THUMBTACK #1	
25' WHITE-BLUE	RY5	THUMBTACK #2	

OPERATION

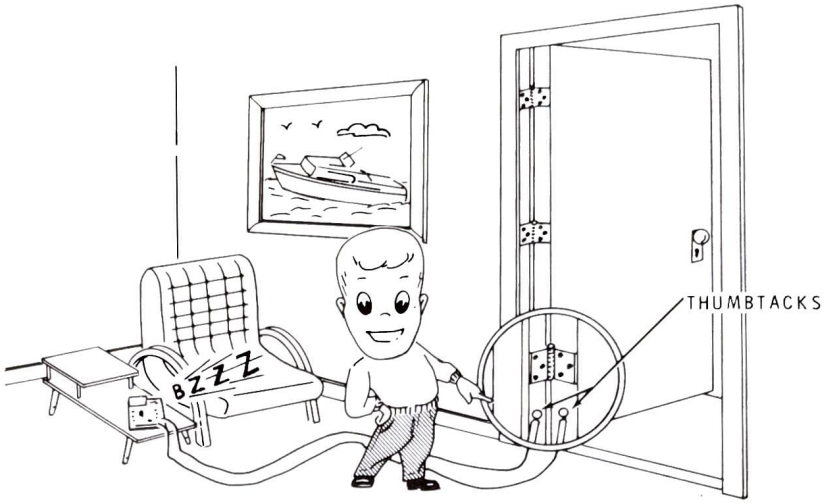
INSTALLING THE BURGLAR ALARM

NOTE: Use unpainted thumbtacks in the next two steps.

( ) Wrap the bare end of one 25' wire around one of the thumbtacks as shown.

( ) Wrap the bare end of the other 25' wire around the other thumbtack.

( ) Press one thumbtack into the edge of the door you want to protect, as shown in the illustration.



( ) Push the other thumbtack into the doorjamb so the two thumbtacks will touch when the door is closed.

( ) Open and close the door a few times; be sure the thumbtacks touch each other when the door is closed. Then open the door.

( ) Turn the CONTROL clockwise until the switch clicks on. A loud tone should be heard with the door open.

( ) Close the door and press the KEY. The RELAY should click and the tone should stop. If it does not stop, be sure the wires are making good contact with the thumbtacks and that the thumbtacks touch each other.

The Burglar Alarm is now ready to be used.

USING THE BURGLAR ALARM

Now, as soon as the door opens, you will hear a tone from the Burglar Alarm. To make the tone stop, close the door and press and release the KEY. This also resets the Burglar Alarm so it is ready to use again. This Burglar Alarm will sound when the thumbtacks are apart, or even if the wires to the tacks are broken or come loose.

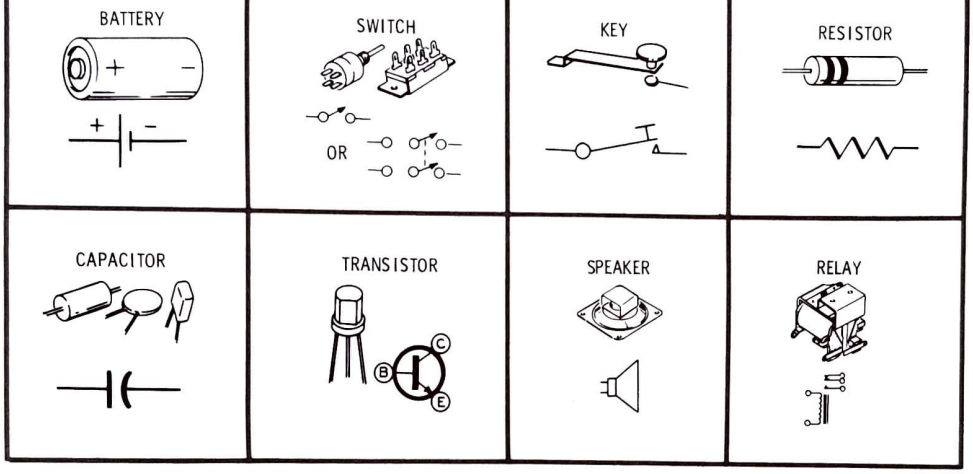
To turn the Burglar Alarm off, turn the CONTROL counterclockwise until the switch clicks off.

NOTE: This circuit draws current from the batteries whenever the CONTROL is turned on, even when you do not hear a tone.

THEORY NOTE: There are many different kinds of burglar alarms, and many of them operate like this burglar alarm. These burglar alarms protect banks, safes, stores, houses, and many other places. Instead of a thumbtack alarm switch, they use small switches that are called microswitches. Sometimes the loud tone is heard right where the alarm is. At other times, the tone is heard at the police station to tell them something is wrong.

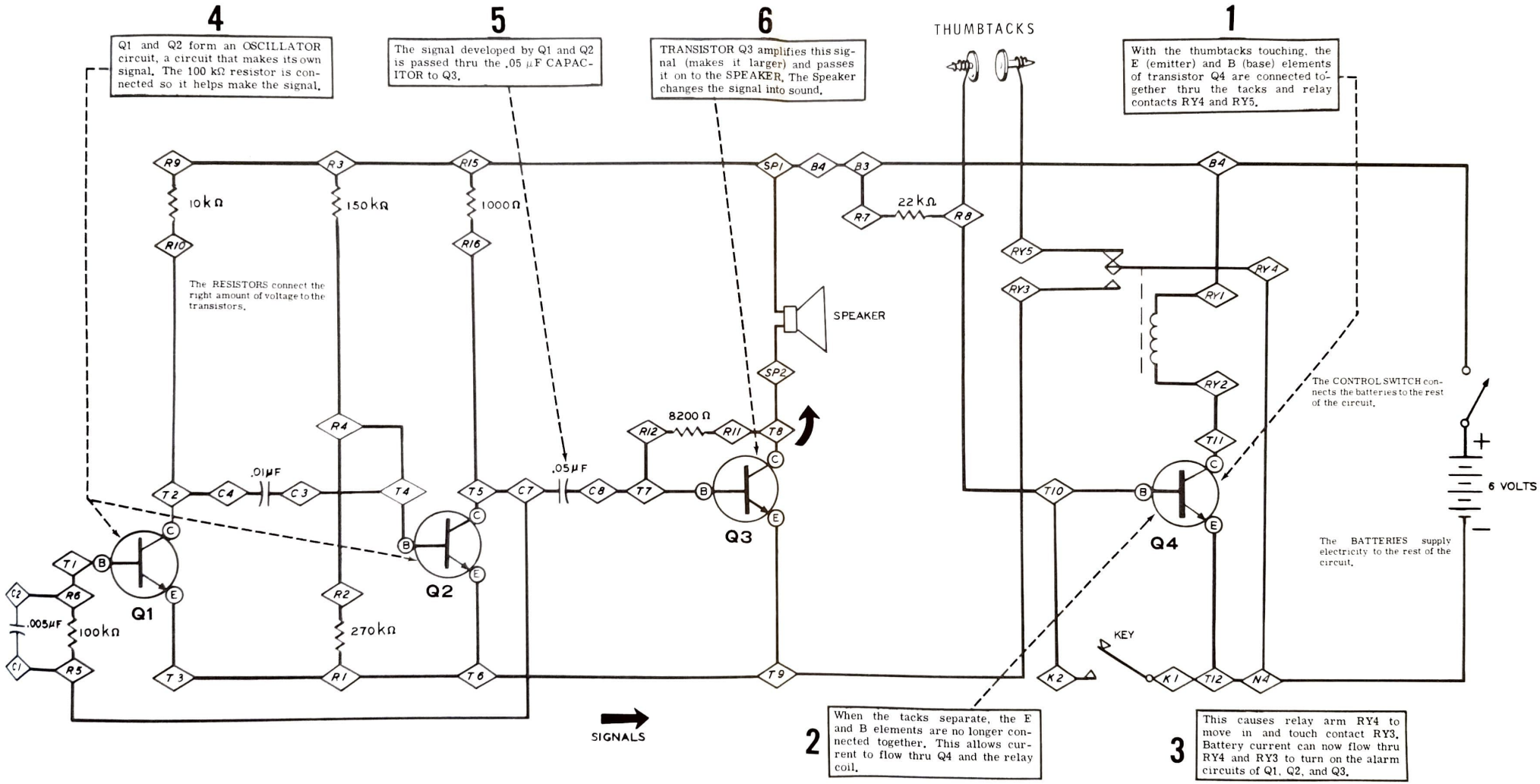
PARTS

OLD PARTS



WHAT HAPPENS IN THE CIRCUIT

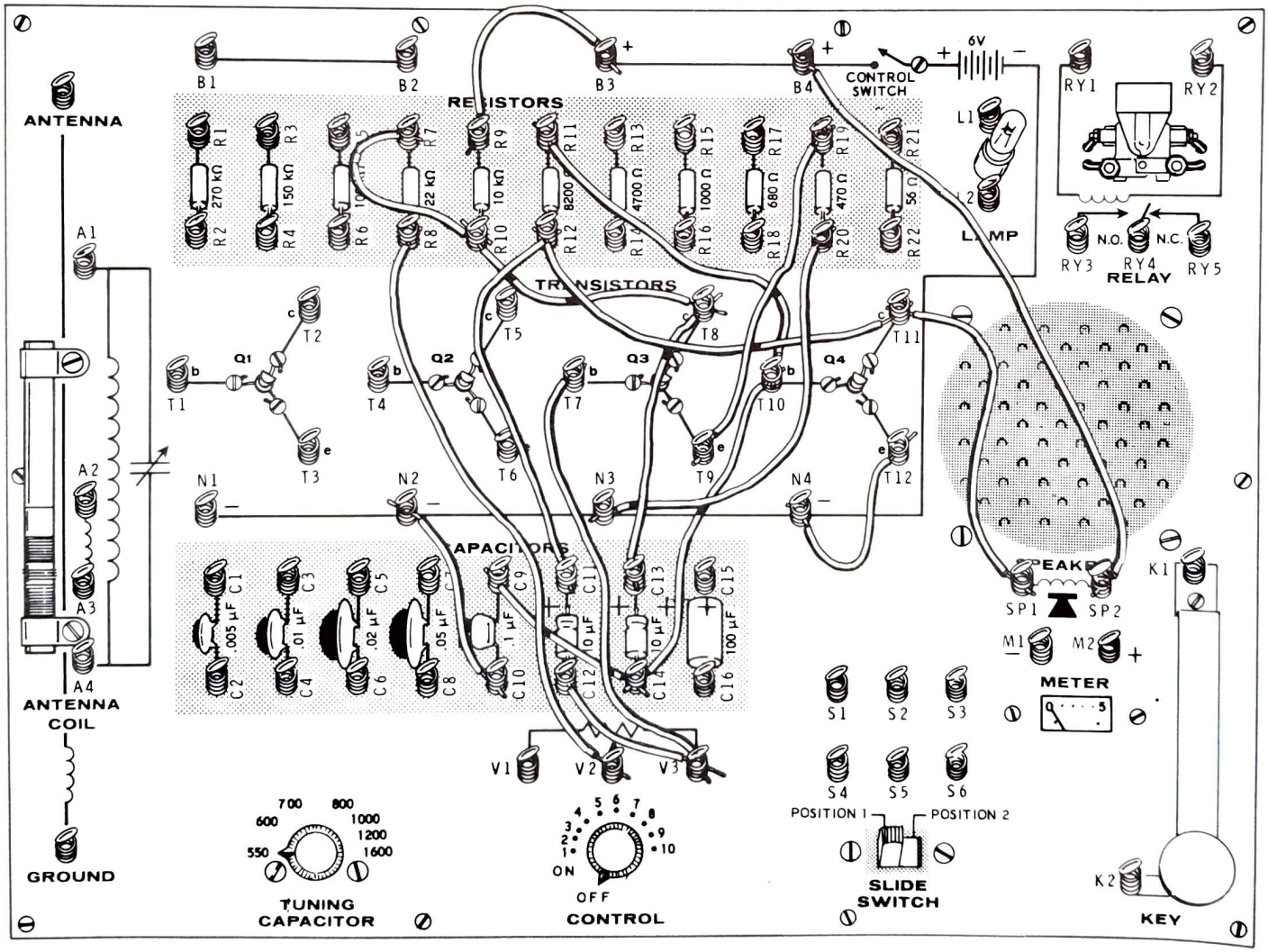
Burglar Alarm



EXPERIMENT 18

Metronome

This Metronome circuit will make a certain number of ticking sounds, or beats, every minute. It can be used to keep time when you play a musical instrument. The beats per minute can be adjusted with the CONTROL from about 80 to 230 beats per minute. (This includes the Adagio, Andante, Allegro, and Presto ranges on a standard metronome.)



WIRING CHART			
USE	FROM	TO	
		FROM	TO
SIX 3" BLACK	B3	R9	
	R7	R10	
	N2	C10	
	C9	C14	
	C12	V3	
	T12	N4	
TWO 4" BROWN	R10	T8	C13
EIGHT 6" RED	R11	T10	C14
	C11	R12	T11
	T11	SP1	
	T9	R19	
	T7	V3	
	R20	N3	
TWO 8" ORANGE	R8	V2	
	B4	SP2	

OPERATION

TESTING

NOTE: Each tick from this Metronome will be a double clicking sound.

( ) Turn the CONTROL clockwise until the switch just clicks ON. You should hear about 20 ticks every 15 seconds.

( ) Turn the CONTROL fully clockwise. You should hear about 19 ticks every 5 seconds.

CALIBRATING

In the following steps, you will find the number of beats per minute you will get for different CONTROL settings. This will help you use the Metronome with musical instruments.

Refer to the following steps and find the number of beats per second at control setting 2.

( ) Turn the CONTROL to 2.

( ) Count the number of ticks (beats) in 6 seconds.

( ) Multiply this number by 10.

( ) Mark this number under 2 in the Beats Per Minute Chart.

BEATS PER MINUTE CHART

CONTROL POSITION	BEATS PER MINUTE
2	
4	
6	
8	
10	

Now repeat these steps for CONTROL settings 4, 6, 8, and 10.

USING THE METRONOME

( ) Turn the CONTROL switch clockwise until the switch clicks on.

( ) Then decide how many beats per minute you want.

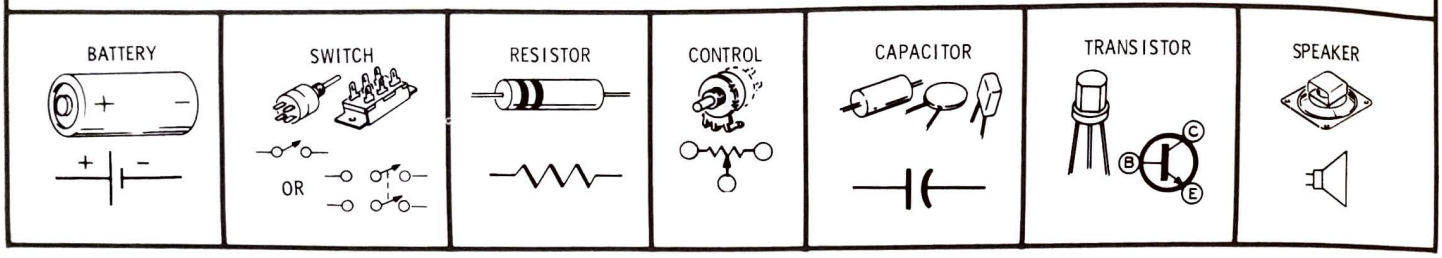
( ) Look at the Beats Per Minute Chart and turn the CONTROL to the setting that will give you the correct number of beats.

The Metronome has many applications in the field of music. Turn it to a slow beat when you are learning a piece of music. Then, as you progress, you can increase the number of beats per minute.

( ) Turn off the CONTROL when you complete the Experiment.

PARTS

OLD PARTS



WHAT HAPPENS IN THE CIRCUIT

Metronome

1

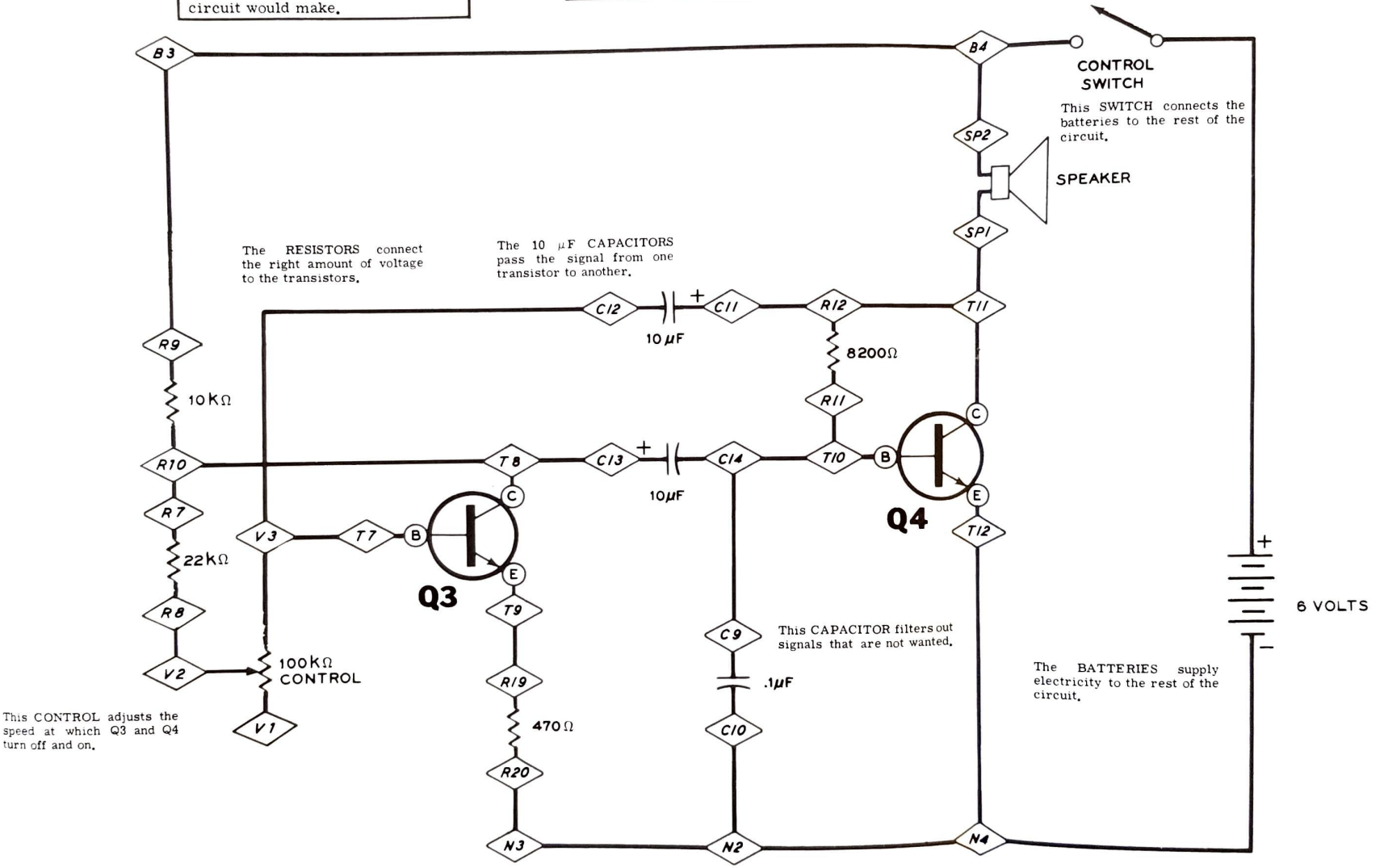
Q3 and Q4 form a MULTIVIBRATOR circuit, a circuit that makes its own signal. This is a different type of signal than an oscillator circuit would make.

2

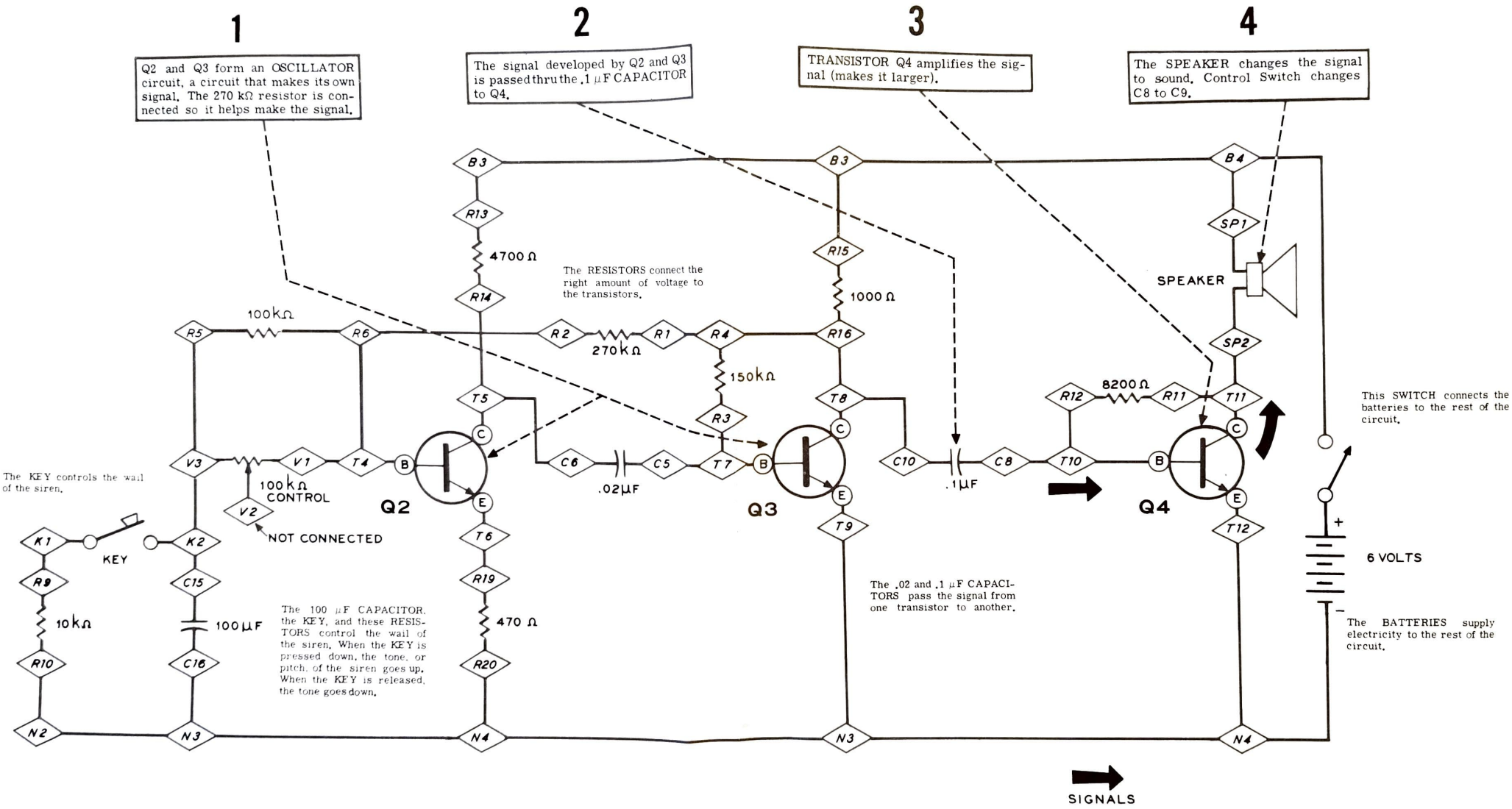
This circuit makes a signal by Q3 and Q4 turning each other on and off. When Q3 is on, Q4 is off. When Q3 is off, Q4 is on.

3

The SPEAKER changes the signal into sound.



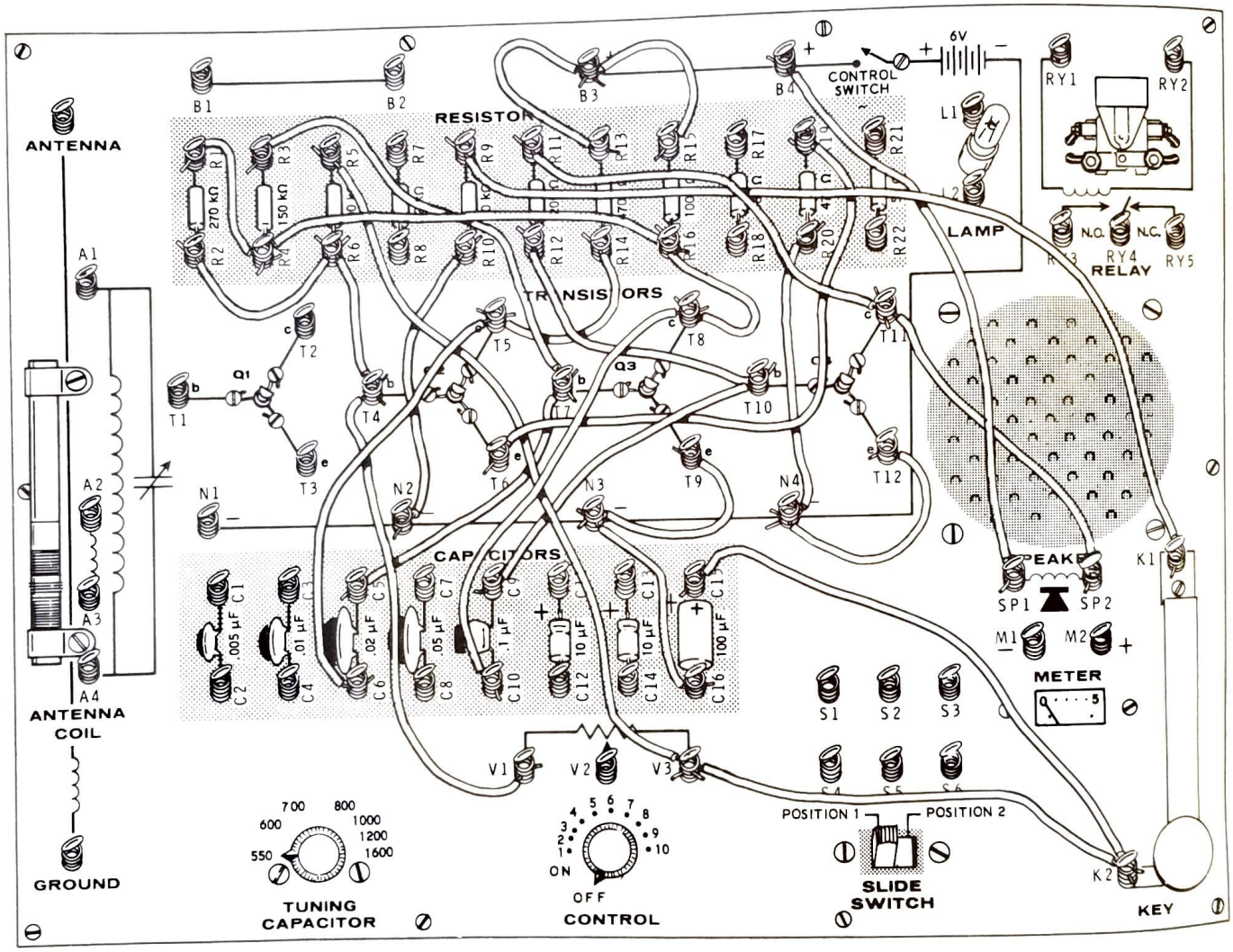
Siren


1
Q2 and Q3 form an OSCILLATOR circuit, a circuit that makes its own signal. The 270 kΩ resistor is connected so it helps make the signal.
2
The signal developed by Q2 and Q3 is passed thru the .1 μF CAPACITOR to Q4.
3
TRANSISTOR Q4 amplifies the signal (makes it larger).
4
The SPEAKER changes the signal to sound. Control Switch changes C8 to C9.
B3
R13
4700 Ω
R14
The RESISTORS connect the right amount of voltage to the transistors.
100kΩ
R5
R6
R2
270kΩ
R1
R4
150kΩ
R3
T5
T8
R15
1000 Ω
R16
B4
SP1
SPEAKER
SP2
R12
8200 Ω
R11
T11
This SWITCH connects the batteries to the rest of the circuit.
V3
V1
T4
100kΩ CONTROL
V2
NOT CONNECTED
Q2
C6
.02μF
C5
T7
Q3
C10
.1μF
C8
T10
Q4
T12
T9
T6
R19
470 Ω
R20
The KEY controls the wail of the siren.
K1
KEY
K2
R9
10kΩ
R10
C15
100μF
C16
The 100 μF CAPACITOR, the KEY, and these RESISTORS control the wail of the siren. When the KEY is pressed down, the tone, or pitch, of the siren goes up. When the KEY is released, the tone goes down.
The .02 and .1 μF CAPACITORS pass the signal from one transistor to another.
6 VOLTS
The BATTERIES supply electricity to the rest of the circuit.
N2
N3
N4
N3
N4
SIGNALS

EXPERIMENT 19

Siren

This Electronic Siren can be used as an alarm or warning device. The pitch of the siren can be made to go up and down by pressing and releasing the KEY. This makes the alarm sound like an official police and fire siren.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
TEN 3" BLACK	R13	B3	R15
	T9	N3	C16
	R2	R6	T4
	R1	R4	
	R14	T5	
	R16	T8	
	N4	T12	
THREE 4" BROWN	N2	R10	
	R12	T10	
	R20	N4	
TEN 6" RED	R3	T7	C5
	R11	T11	SP2
	R19	T6	
	R4	R16	
	T10	C9	
	C10	T8	
	T5	C6	
	T4	V1	
THREE 8" ORANGE	B4	SP1	
	C15	K2	V3
ONE 10" YELLOW	R5	V3	
ONE 12" BLACK	R9	K1	

OPERATION

TESTING THE SIREN

( ) Turn the CONTROL to ON.

( ) The sound should increase in pitch and then level off.

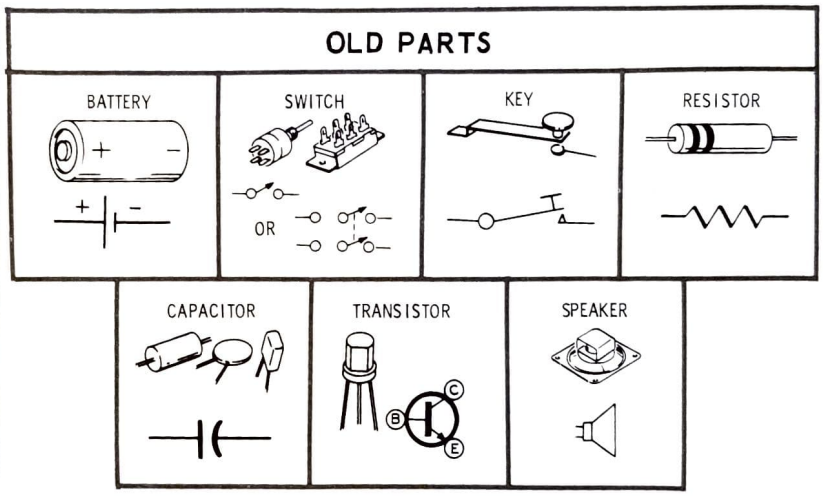
( ) Press the KEY.

( ) The sound should decrease in pitch and then level off.

( ) By pressing the KEY and lifting it at regular intervals, the siren will wail up and down in pitch just like a real siren.

( ) Turn off the CONTROL when you complete the Experiment.

PARTS



WHAT HAPPENS IN THE CIRCUIT

See the fold-out from Page 92.

THINGS TO DO AFTER THE EXPERIMENT

FAST CYCLE SIREN

( ) Disconnect the wire at C16 and connect it to C14.

( ) Disconnect the wire at C15 and connect it to C13.

( ) Turn on the CONTROL, and operate the KEY as before.

ENGLISH HORN

( ) Disconnect the wire from C14 and connect it to C16.

( ) Disconnect the wire at C13 and connect it to C15.

( ) Connect an 8" orange wire from C15 to R8.

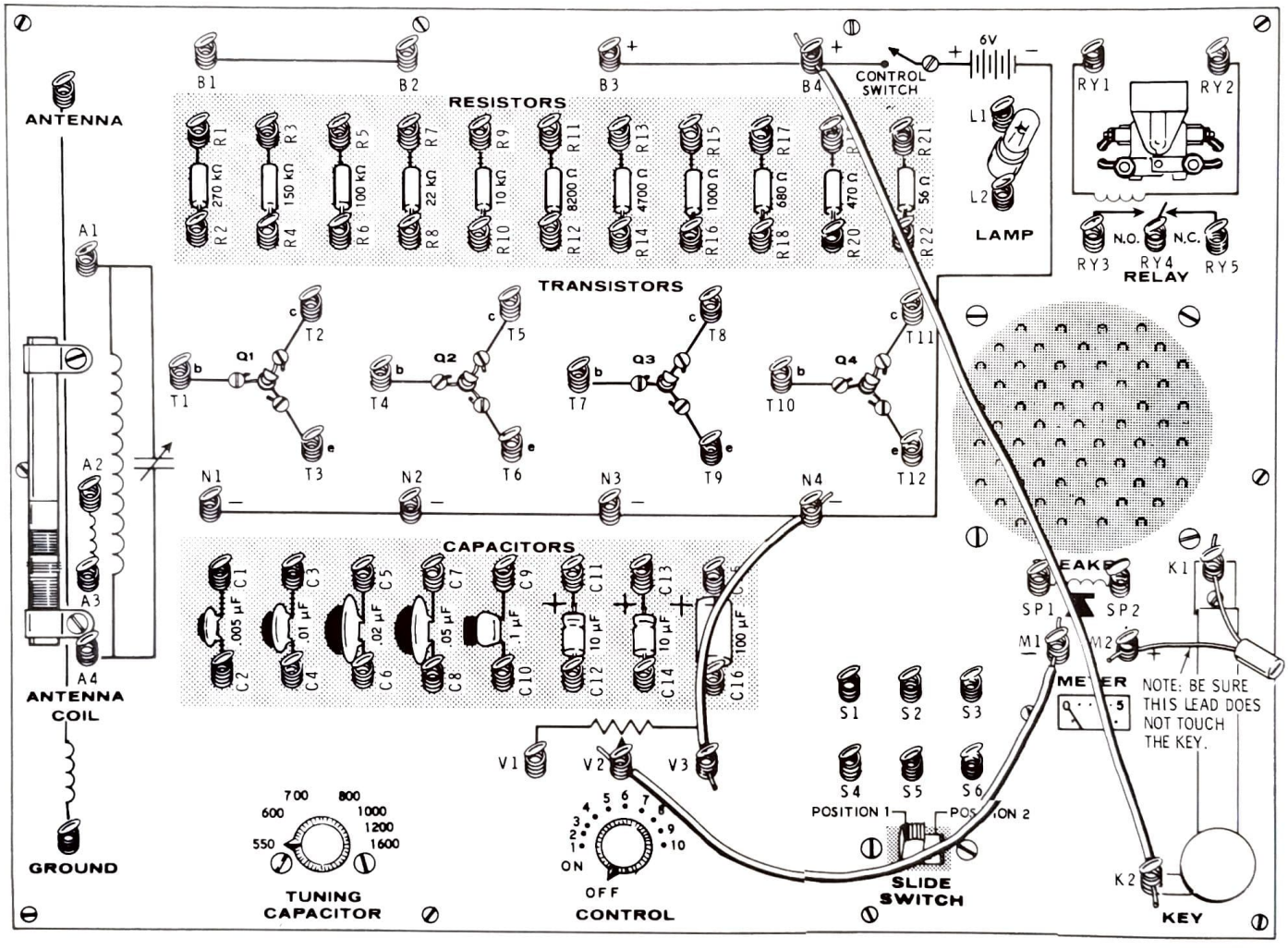
( ) Connect a 14" brown wire from R7 to K2.

( ) Turn on the CONTROL. Then operate the KEY as before, but at a faster rate.

EXPERIMENT 20

Light Meter

A light meter is used to measure the brightness of light. One is often used by photographers to make sure the correct amount of light is used for each photograph.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
ONE 4" BROWN	N4	V3	
ONE 8" ORANGE	M1	V2	
ONE 12" BLACK	B4	K2	
LDR *	M2	K1	

* LIGHT DEPENDENT RESISTOR

OPERATION

( ) Turn the CONTROL to position 1 and press down on the KEY. The Meter pointer should move up from the 0 point.

( ) Put the LDR near a lamp. Then turn the CONTROL clockwise until the Meter points to 5.

( ) Put your hand over the LDR. The Meter pointer should move toward 0.

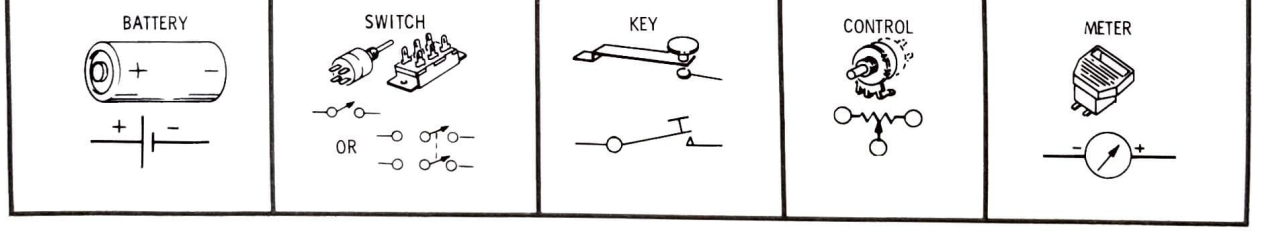
This Experiment shows you how a professional light meter works. When dim light hits the LDR, the Meter pointer does not indicate very high. With brighter light, the pointer indicates farther up-scale.

On a professional light meter, the meter has special numbers on it. Before he takes a picture, the photographer uses his light meter to measure the brightness of the light. Then he uses this number to adjust his camera for the best picture.

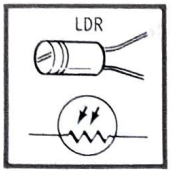
( ) Turn off the CONTROL when you complete the Experiment.

PARTS

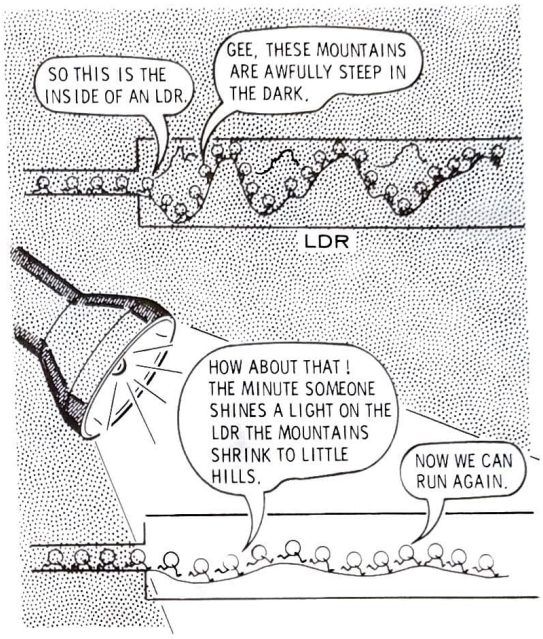
OLD PARTS



NEW PARTS

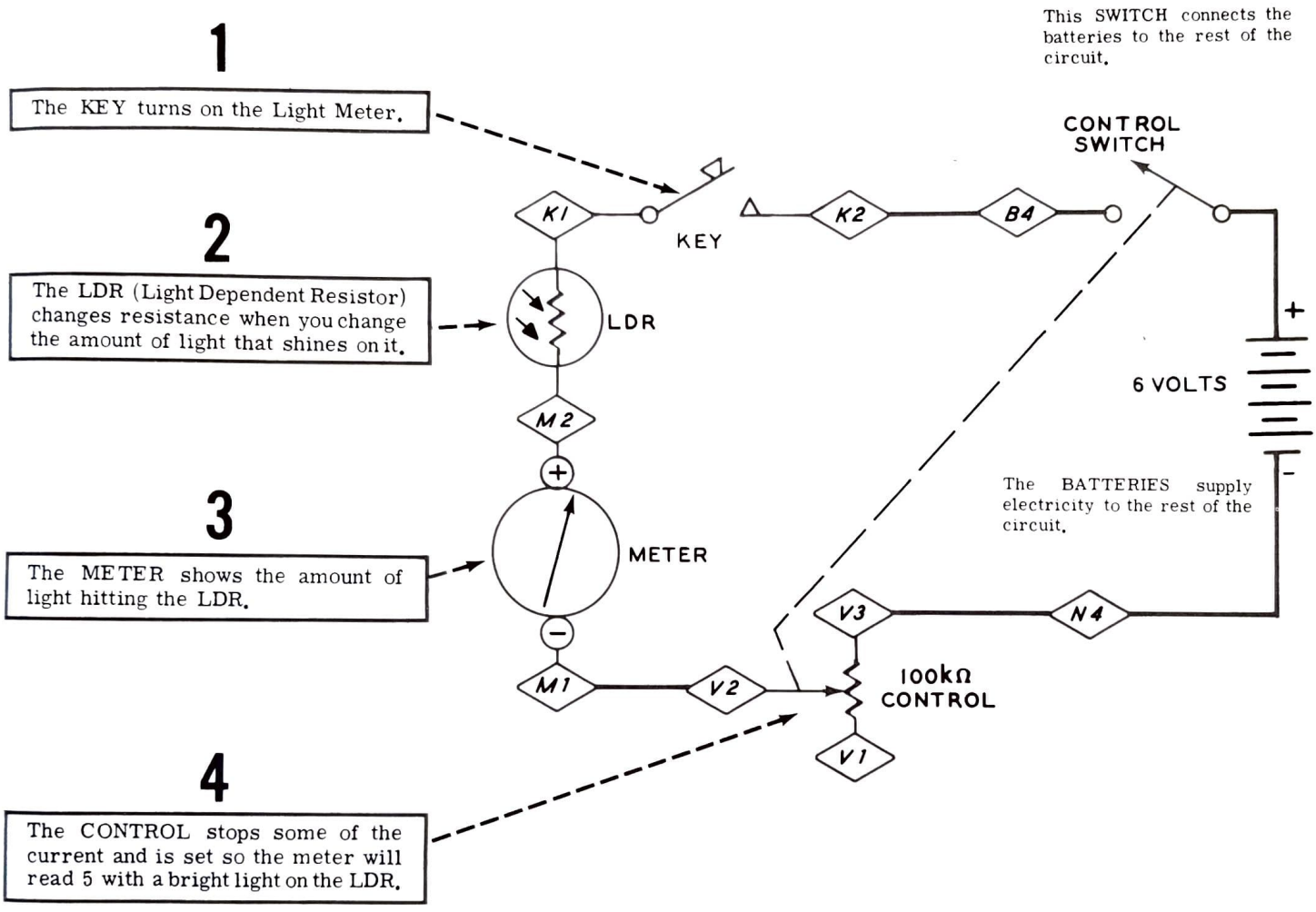


LDR - An LDR (Light Dependent Resistor) is a special type of resistor. Its electrical size (resistance) changes when you change the amount of light that shines on it. In the dark, its electrical size is very high. Then its electrical size gets smaller and smaller as more and more light shines on it. An LDR is also called a Photo Resistor.



WHAT HAPPENS IN THE CIRCUIT

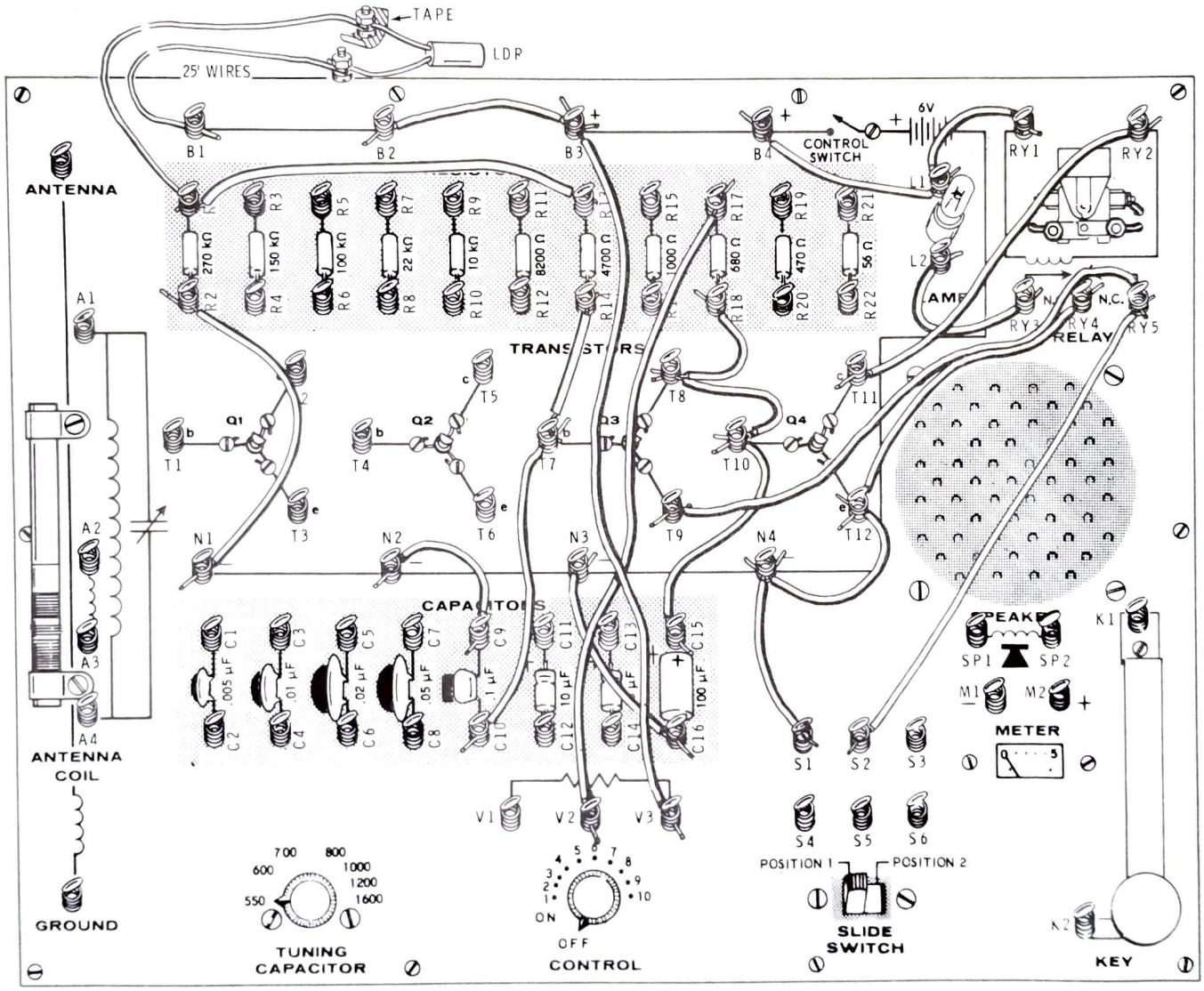
Light Meter



EXPERIMENT 21

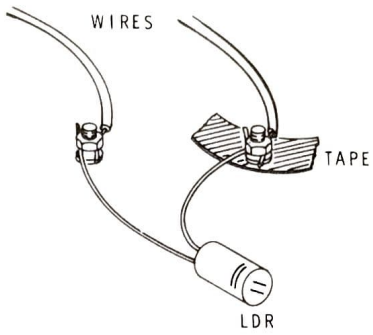
Light Sensing Alarm

When the lights in your room stop shining on the LDR, this Light Sensing Alarm will turn on the Lamp. Circuits like this are used to light emergency lamps (from batteries) in hospitals and factories when storms cut off the electric power.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
ELEVEN 3" BLACK	B2	B3	
	B4	L1	RY1
	R18	T8	T10
	N2	C9	
	N3	C16	
	N4	T12	
	L2	RY3	
	R14	T7	
	N4	S1	
TWO 4" BROWN	R2	N1	
	T10	C15	
FOUR 6" RED	R1	R13	
	RY2	T11	
	RY4	T12	
	T7	C10	
TWO 8" ORANGE	S2	RY5	T9
TWO 10" YELLOW	V2	R17	
	B3	V3	
25' WHITE	B1		
25' WHITE-BLUE	R1		

OPERATION



CONNECTING THE LDR

( ) Fasten 6-32 nuts loosely on two 6-32 x 1/4" screws.

( ) Fasten one of the 25' wires under each screw.

( ) Spread the LDR leads apart.

( ) Wrap one of the LDR leads under each screw. Then tighten the screws.

( ) Wrap tape around one of the screws so it cannot accidentally touch (short circuit) the other screw.

TESTING

( ) Face the LDR toward a light but away from the Lamp on the Workshop.

( ) Place the SLIDE SWITCH in Position 1.

( ) Block the light to the LDR with your hand and turn the CONTROL clockwise to a point where the Lamp just lights.

( ) Uncover the LDR. The Lamp should turn off. This is called a "nonlatching" circuit because the Lamp will turn on and off each time you block and unblock the light to the LDR.

( ) Place the SLIDE SWITCH in Position 2 and block the light to the LDR. The Lamp should light.

( ) Now unblock the LDR and notice that the Lamp stays lit even if you block the LDR again. This is called a "latching" circuit because the Lamp is held (or "latched") on until you place the SLIDE SWITCH back in Position 1 again.

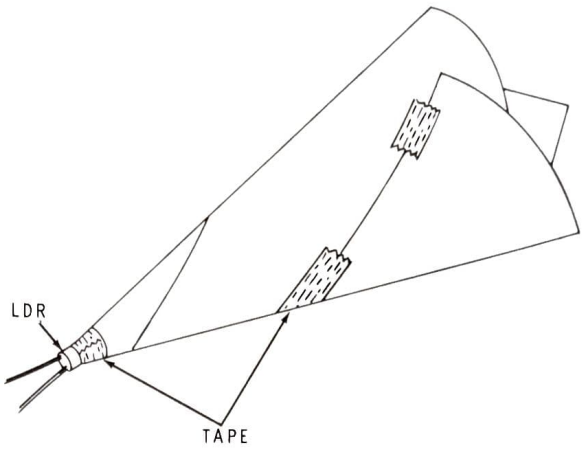
USING THE ALARM

In the next three steps you will build a paper funnel and attach it to the LDR. This will collect light and direct it to the LDR.

( ) Make a paper funnel out of white thin cardboard or heavy paper. Hold it together with tape. NOTE: Have the white side of the paper or cardboard on the inside.

( ) Tape the LDR in the small end of the paper funnel.

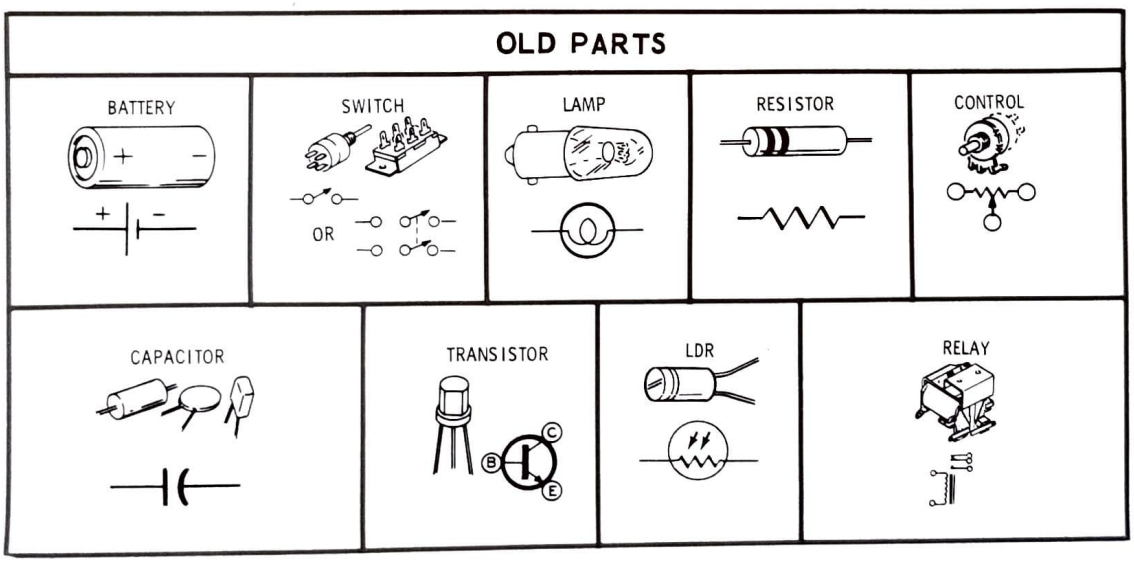
( ) Fasten the LDR (with the funnel) in place where you want to use it. This could be in a room, for example, where it would act as a safety light and turn on the Lamp when the lights go off.



You could also use this alarm to tell when someone passes thru a doorway. Just have a light shining across the doorway on the LDR. Then, if someone goes thru the doorway, his shadow will fall on the LDR and the Lamp will light.

After the LDR, Workshop, (and light?) are set up where you want to use them, repeat the steps under "Testing" to adjust the circuit again before you use it. Either the latching (SLIDE SWITCH, Position 1) or the nonlatching (Position 2) circuit may be used.

PARTS



WHAT HAPPENS IN THE CIRCUIT

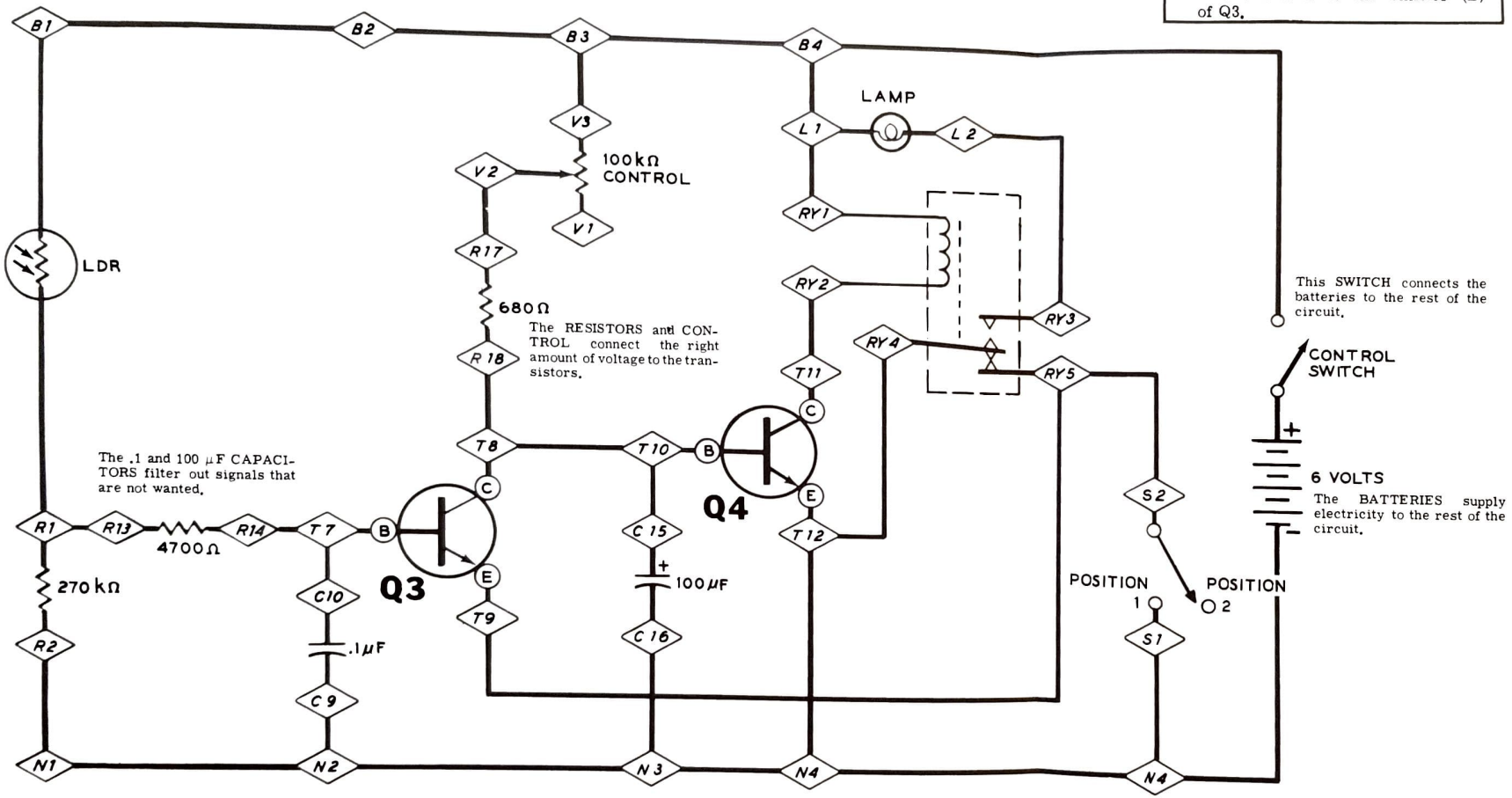
Light Sensing Alarm

1 When the light shines on the LDR. ➡

A. Q3 is turned on and current flows thru it.

B. Q4 is turned off; therefore no current goes thru the RELAY COIL.

C. RELAY arm RY4 touches contact RY5. Therfore, the Lamp does not light. Battery current flows thru RY4 and RY5 to the emitter (E) of Q3.



2 When the light stops shining on the LDR. ➡

A. The LDR resistance increases. This turns Q3 off.

B. When Q3 turns off, it makes Q4 turn on. Current then flows thru Q4 and the RELAY COIL.

C. This moves RELAY ARM RY4 over to contact RY3.

D. This lights the LAMP by routing battery current thru it.

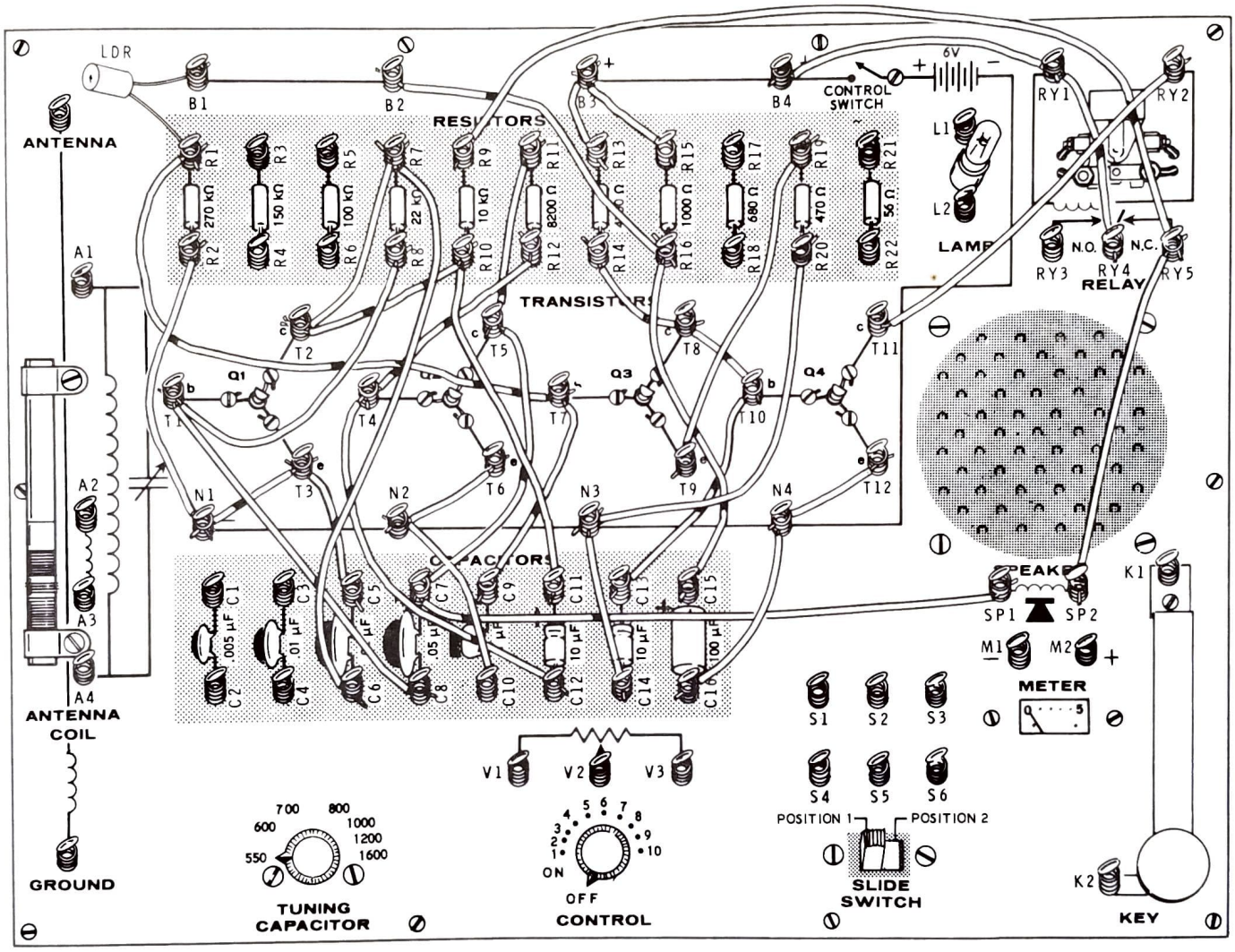
E. If the SLIDE SWITCH is in Position 2, the lamp will stay on - even when the light shines on the LDR again - until this SWITCH is pressed to 1 and put back on 2 again.

F. With the SLIDE SWITCH in Position 1, the Lamp will only be turned off while the light shines on the LDR.

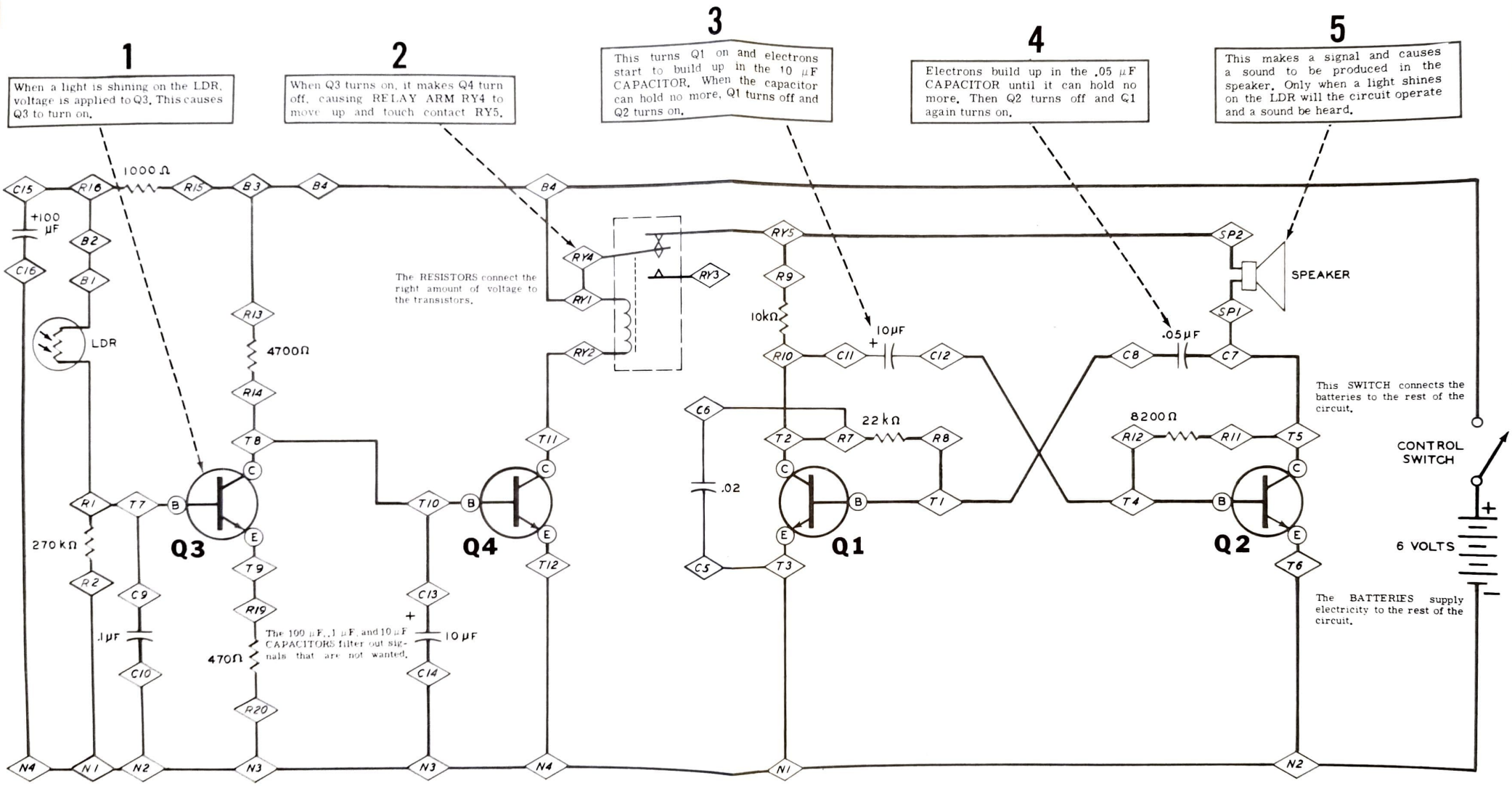
EXPERIMENT 22

Electronic Target Hit Alarm

This circuit will cause an alarm to sound when you hit the LDR with a light beam.



Electronic Target Hit Alarm



WIRING CHART			
USE	FROM	TO	
		FROM	TO
FOURTEEN 3" BLACK	R15	B3	R13
	R11	T5	
	T6	N2	C10
	R7	T2	R10
	C5	T3	N1
	R14	T8	T10
	N3	C14	
	T12	N4	C16
EIGHT 4" BROWN	B4	RY1	RY4
	R2	N1	
	R8	T1	
	R12	T4	
	T5	C7	
	T7	C9	
	T10	C13	
NINE 6" RED	B2	R16	C15
	T1	C8	
	C11	R10	
	T4	C12	
	T11	RY2	
	SP2	RY5	
	R19	T9	
	R20	N3	
TWO 8" ORANGE	R1	T7	
	C6	R7	
TWO 10" YELLOW	R9	RY5	
	C7	SP1	
LDR	B1	R1	

OPERATION

TESTING

( ) Place the LDR in the dark.

( ) Turn the CONTROL to ON.

( ) Shine the beam from a flashlight on the LDR. The alarm should sound.

( ) Remove the light. The alarm should turn off.

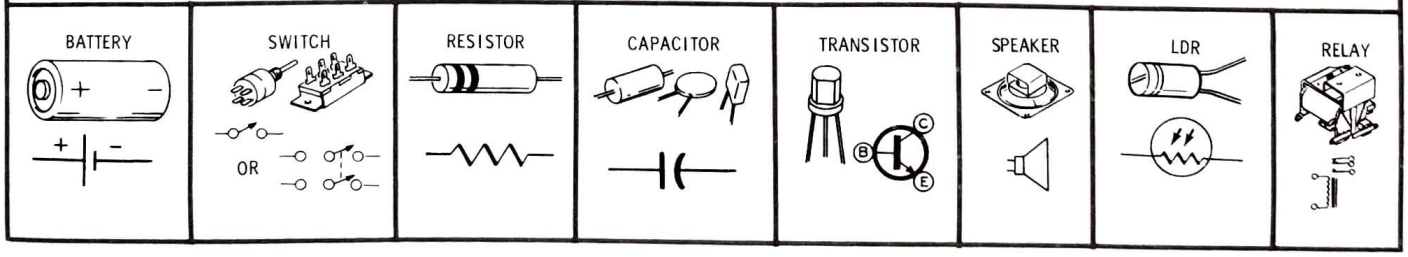
USING THE ALARM

Set up the LDR at one end of a dimly lit room. Aim the beam from a pushbutton flashlight at the LDR.

Electronic guns like this are used in target practice. Use this Target Hit Alarm as a game with your friends. Turn off the CONTROL when you are not using this circuit.

PARTS

OLD PARTS



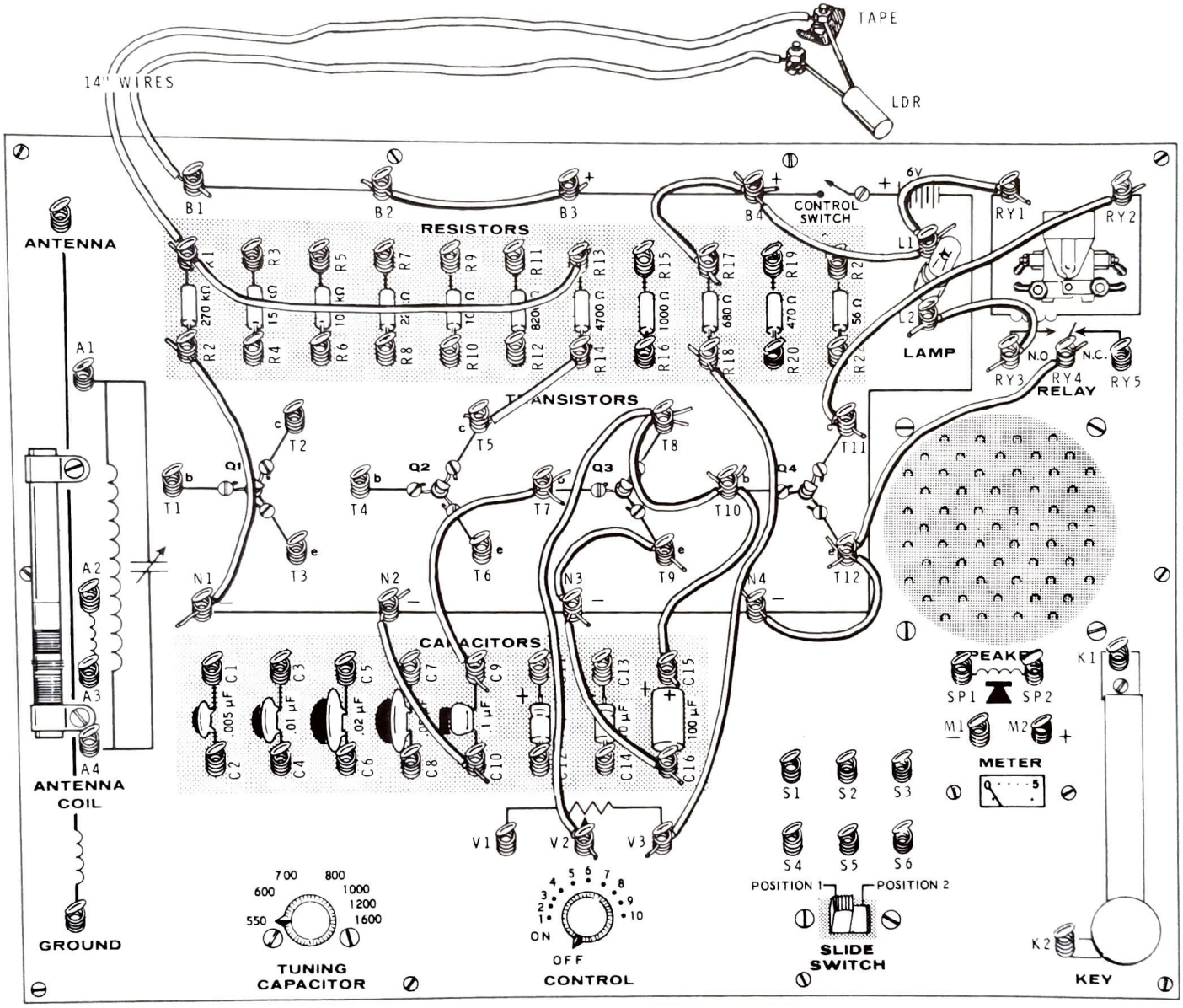
WHAT HAPPENS IN THE CIRCUIT

See the fold-out from Page 102.

EXPERIMENT 23

LDR Flasher

In this Experiment, you will build a Light Dependent Oscillator that will turn itself On and Off with the Lamp and the LDR.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
ELEVEN 3" BLACK	B2	B3	
	B4	R17	
	B4	L1	RY1
	RY3	L2	
	T8	T10	
	C10	N2	
	N4	T12	
	T9	N3	C16
	R14	T7	
THREE 4" BROWN	R2	N1	
	T10	C15	
	C9	T7	
THREE 6" RED	R13	R1	
	T11	RY2	
	T12	RY4	
TWO 8" ORANGE	V3	R18	
	V2	T8	

OPERATION

CONNECTING THE LDR

( ) Fasten 6-32 nuts loosely on two 6-32 x 1/4" screws.

( ) Fasten a 14" brown wire under each screw.

( ) Spread the LDR leads apart.

( ) Wrap one of the LDR leads under each screw. Then tighten the screws.

( ) Wrap tape around one of the screws so it can not accidentally touch (short circuit) the other screw.

( ) Attach the other ends of the 14" brown wires to B1 and R1.

USING THE LDR FLASHER

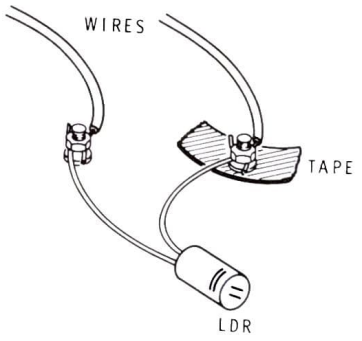
( ) Place the Workshop in a dimly lit room.

( ) Face the LDR toward and about 4" away from the Lamp on the Workshop.

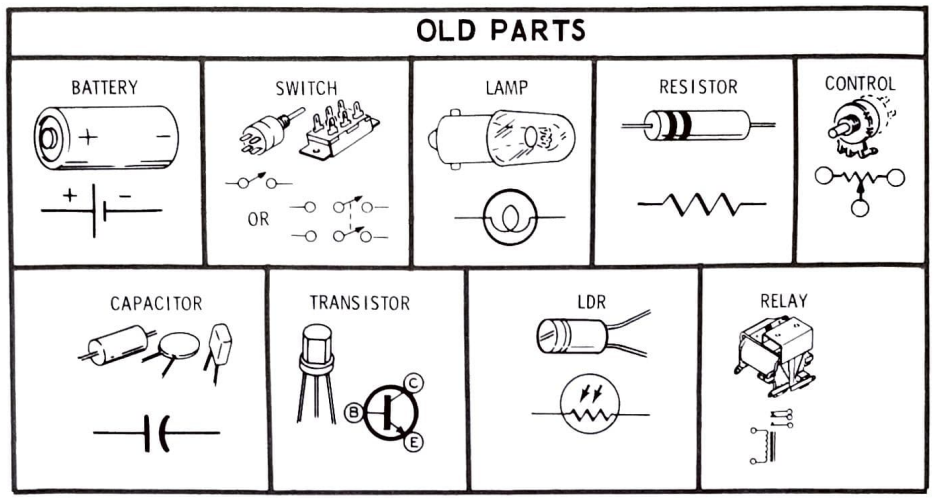
( ) Turn the CONTROL clockwise slowly until the Lamp begins to turn on and off.

( ) Move the LDR closer to and farther away from the Lamp and see how the speed varies. Also try putting some things between the Lamp and LDR. You might also see how much light you can have in the room before the relay will stop flashing.

( ) Turn off the CONTROL when the experiment is completed.



PARTS


OLD PARTS
BATTERY
SWITCH
OR
LAMP
RESISTOR
CONTROL
CAPACITOR
TRANSISTOR
C
B
E
LDR
RELAY

WHAT HAPPENS IN THE CIRCUIT

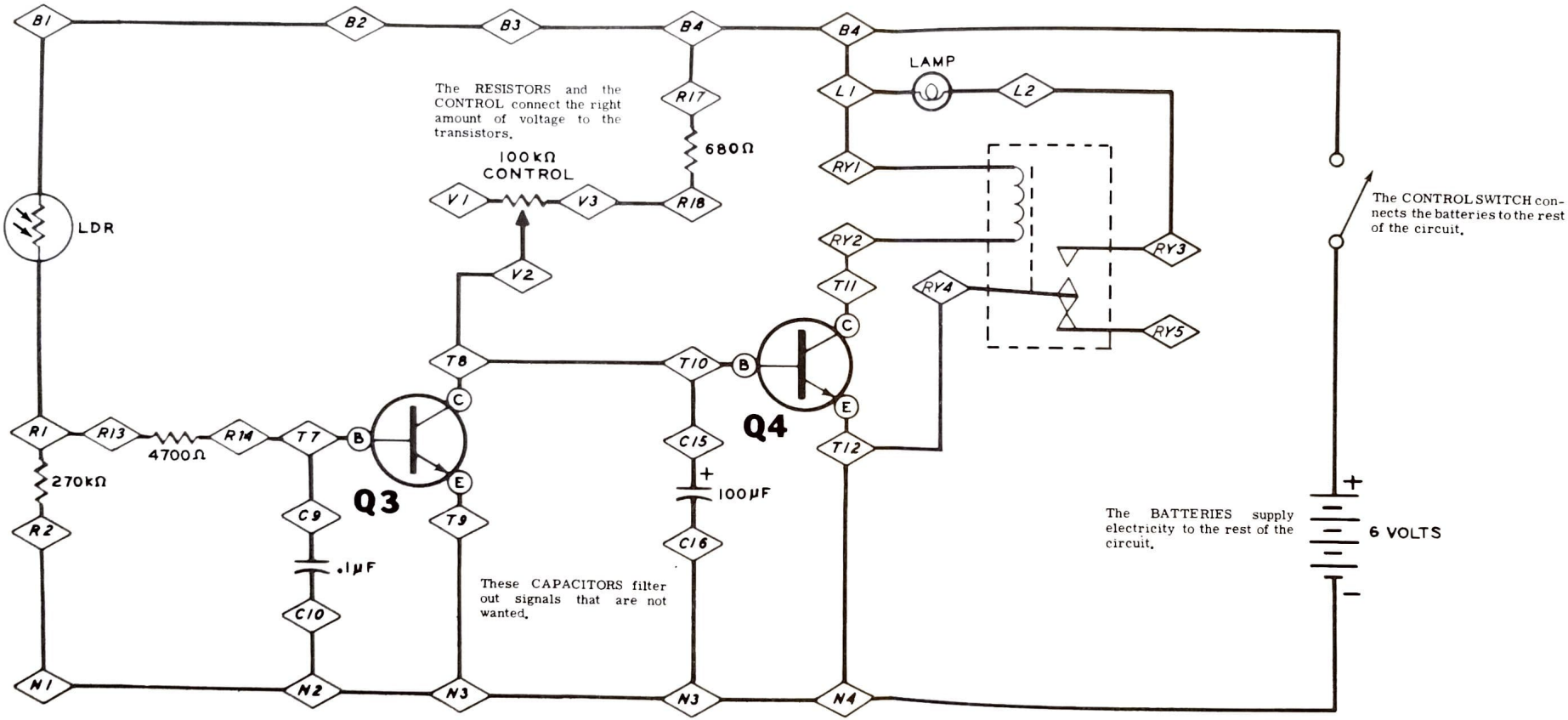
LDR Flasher

1. When light shines on the LDR. ➡

A. Q3 is turned on and current flows thru it.

B. When Q3 turns on it makes Q4 turn off. Therefore no current goes thru the RELAY COIL.

C. RELAY ARM RY4 touches contact RY5. The LAMP does not light.



2. When light stops shining on the LDR. ➡

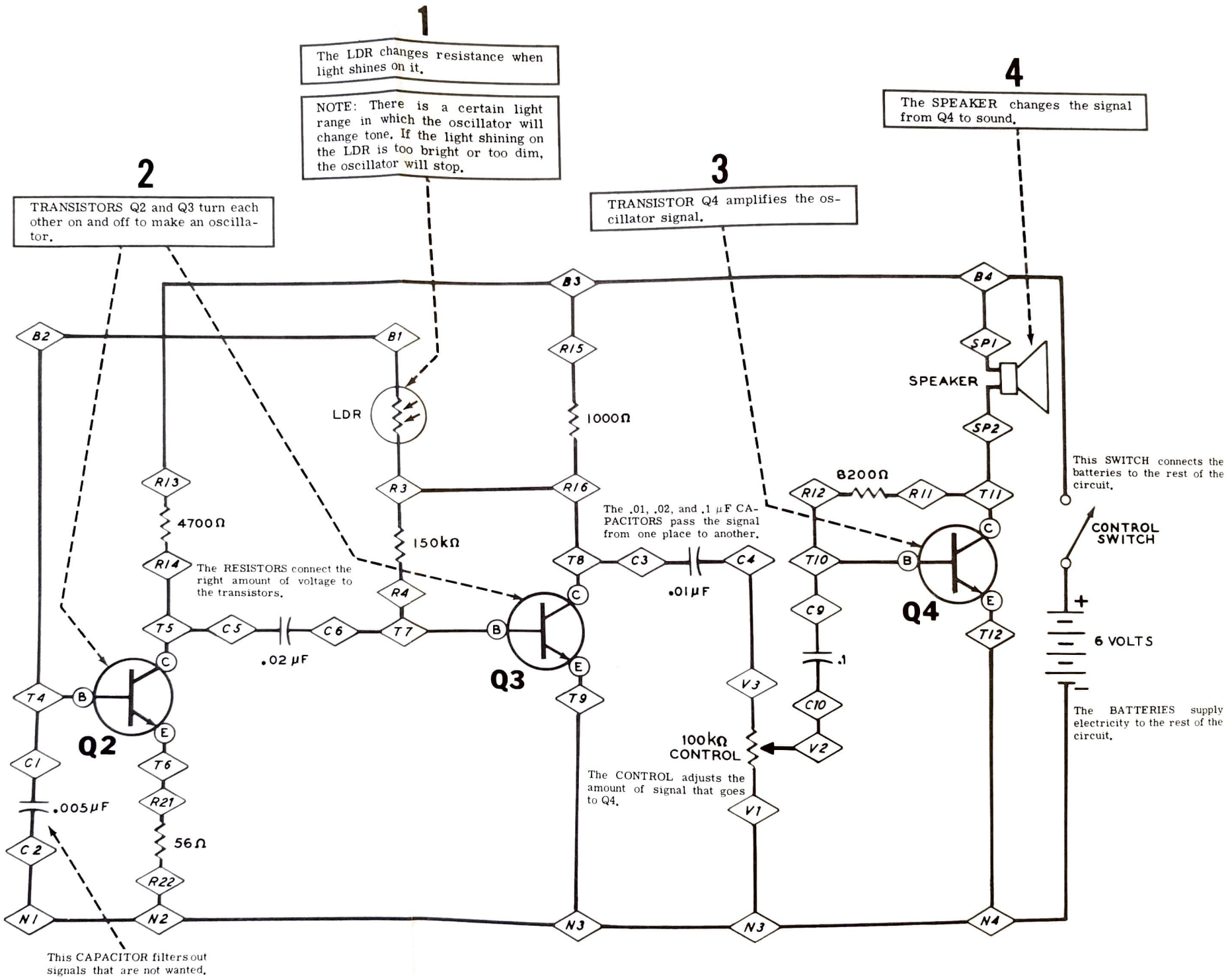
A. Q3 is turned off.

B. When Q3 turns off it makes Q4 turn on. Current then flows thru Q4 and the RELAY COIL.

C. This moves RELAY ARM RY4 over to contact RY3. Battery current now flows thru these two contacts and lights the LAMP.

D. When the LAMP goes on, it shines on the LDR and the whole process starts over again.

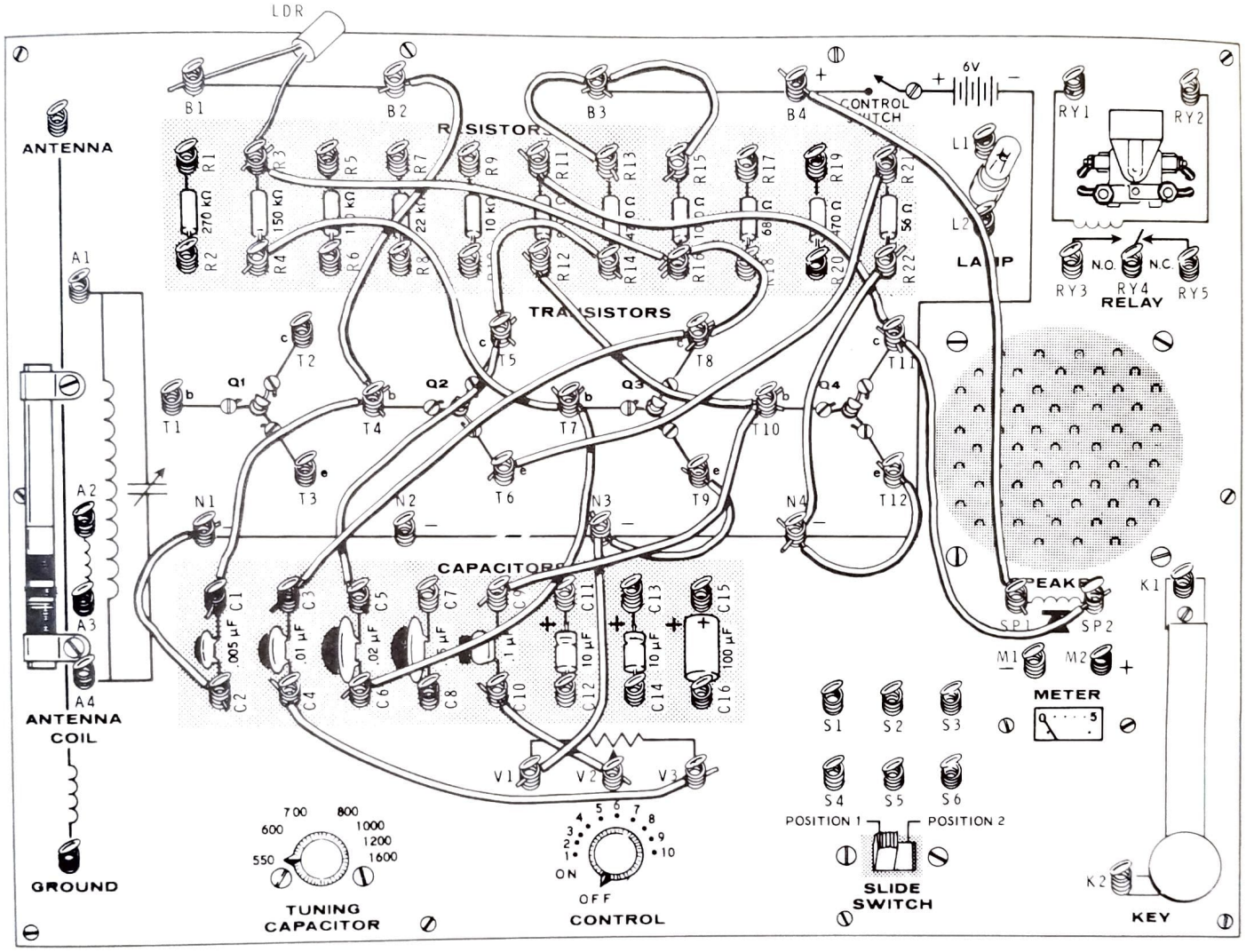
LDR Oscillator



EXPERIMENT 24

LDR Oscillator

This circuit has an LDR connected to an oscillator. Just change the amount of light to the LDR and the tone you hear will change accordingly.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
EIGHT 3" BLACK	R13	B3	R15
	R16	T8	
	R14	T5	
	N1	C2	
	N3	T9	
	N4	T12	
	V2	C10	
FOUR 4" BROWN	R12	T10	
	C1	T4	
	R22	N4	
	V1	N3	
NINE 6" RED	B2	T4	
	R4	T7	C6
	R11	T11	SP2
	T5	C5	
	R3	R16	
	C4	V3	
	T10	C9	
THREE 8" ORANGE	B4	SP1	
	C3	T8	
	T6	R21	
LDR	B1	R3	

OPERATION

( ) Face the LDR toward the room light.

( ) Turn the CONTROL clockwise to ON. You should hear a tone. If you do not hear a tone, move your hand close to the LDR to partly block the light. (NOTE: If the light shining on the LDR is too bright or too dim, the Oscillator will stop working.)

( ) Move your hand back and forth, close to and away from the LDR. This will make the tone change. Try playing a tune by moving your hand back and forth.

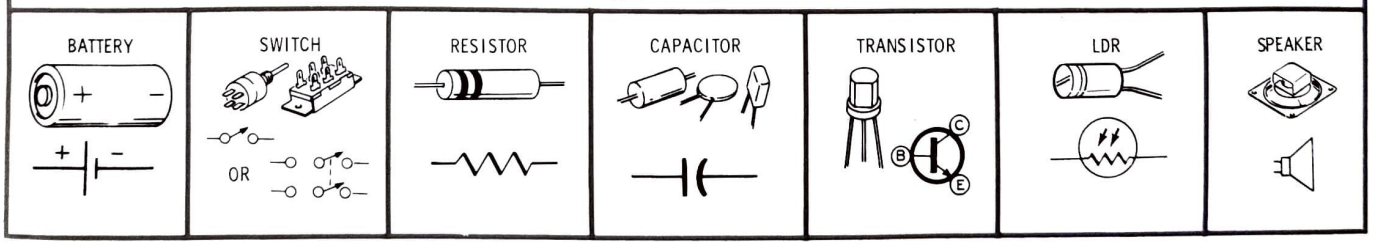
NOTE: A musical instrument called a "theremin" (ther' a min) operates and is played very much like this. The musical pitch (or tone) of the theremin changes when the player's hands move back and forth near it.

A circuit like this LDR Oscillator could also be used in a Weather satellite. The clouds would change the amount of light that reaches the LDR. This would change the tone of an oscillator, and the tone-change information could then be connected to a transmitter that sends this information back to earth.

( ) Turn off the CONTROL when you complete the Experiment.

PARTS

OLD PARTS



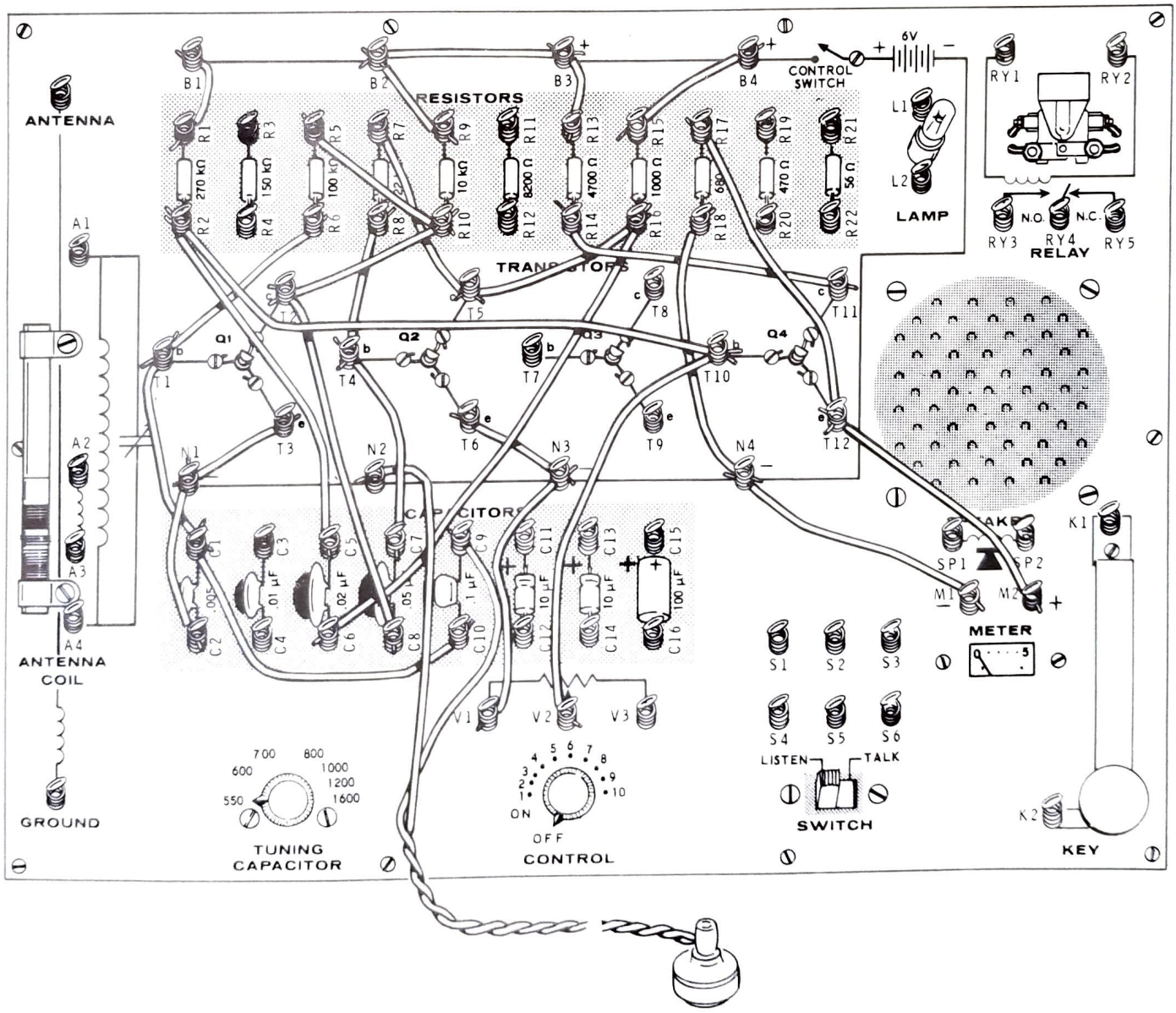
WHAT HAPPENS IN THE CIRCUIT

See the fold-out from Page 108.

EXPERIMENT 25

Sound Level Meter

In this Experiment you will measure the loudness of sounds coming from radios, people's voices, or other sound sources. Sound level meters are used by engineers at broadcast stations and recording studios. They are also used by scientists and engineers to measure the sound levels in airplanes, automobiles, and factories.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
THIRTEEN 3" BLACK	T3	N1	C2
	R5	R10	T2
	R7	T5	R16
	R13	B3	B2
	R15	B4	
	T6	N3	
	B1	R1	
	R8	T4	
	B2	R9	
SIX 4" BROWN	R6	T1	C1
	T4	C7	
	N3	V1	
	R18	N4	M1
SEVEN 6" RED	V2	T10	
	R2	C5	
	T2	C8	
	C1	C10	
	R14	T11	
	R17	T12	M2
TWO 8" ORANGE	R16	C6	
	R2	T10	
EARPHONE	N2	C9	

OPERATION

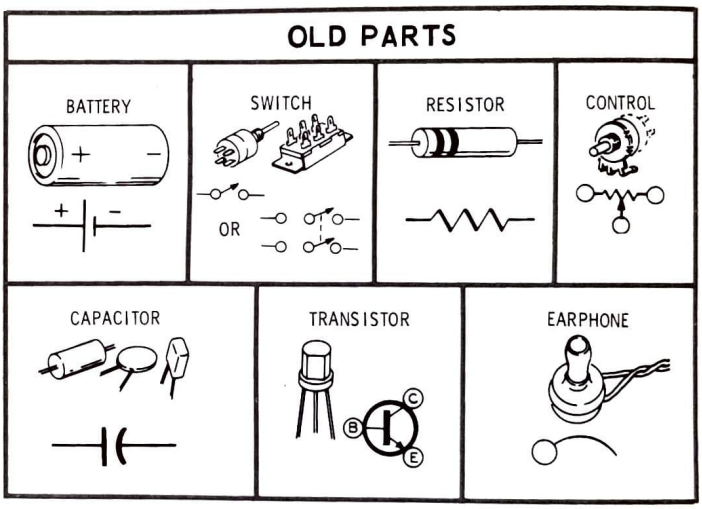
( ) Turn the CONTROL clockwise until the Meter reads "0".

NOTE: The Earphone will be used as a microphone in this Experiment.

The Sound Level Meter is now ready to use. Place the Earphone near a radio and read the Meter indication. Move the earphone away from the radio and see how the sound level changes with distance from a sound source. Measure other sounds for loudness (talk into the Earphone, etc.).

( ) Turn off the CONTROL when you complete the Experiment.

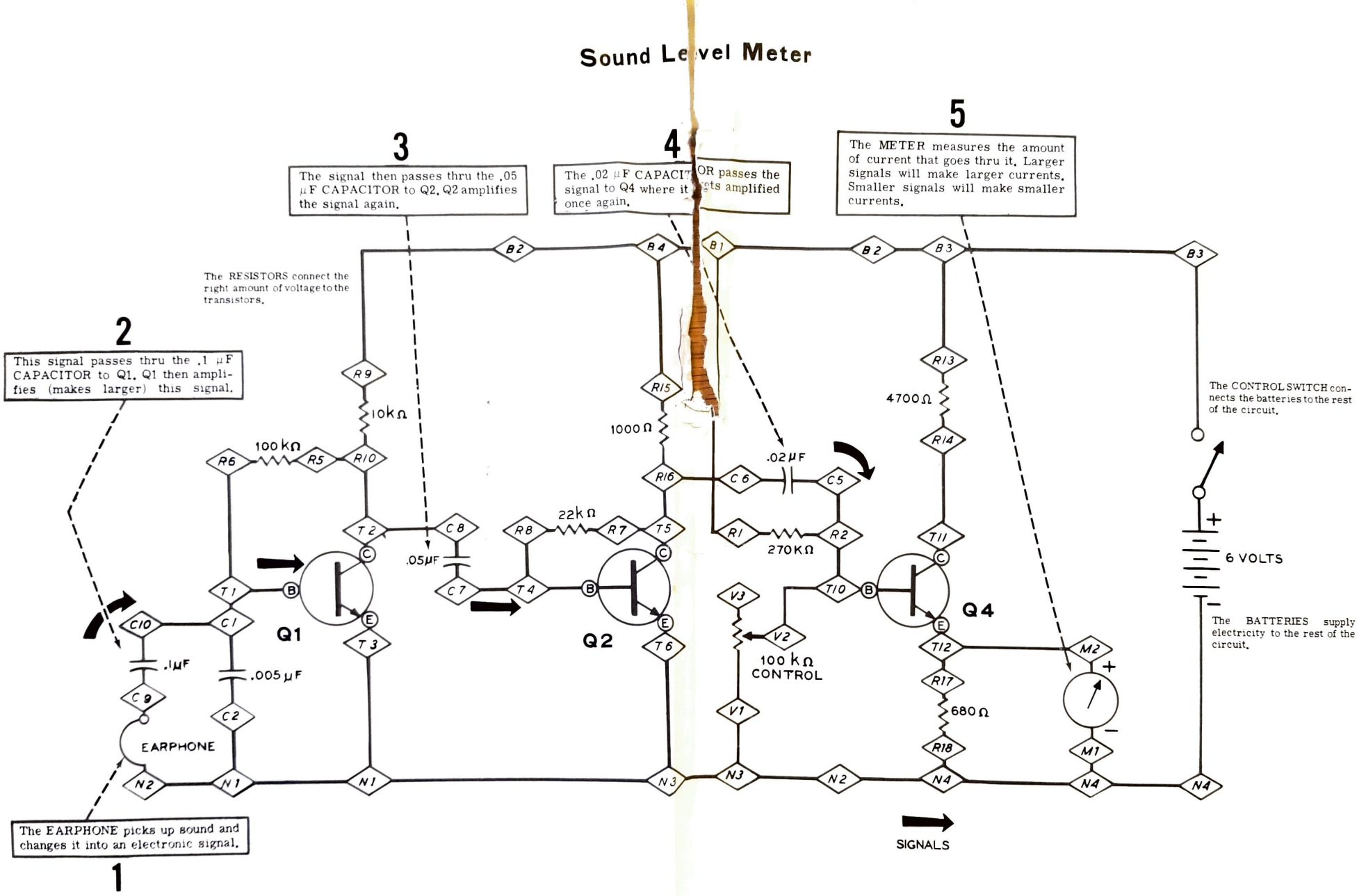
PARTS



WHAT HAPPENS IN THE CIRCUIT

See the fold-out from this Page.

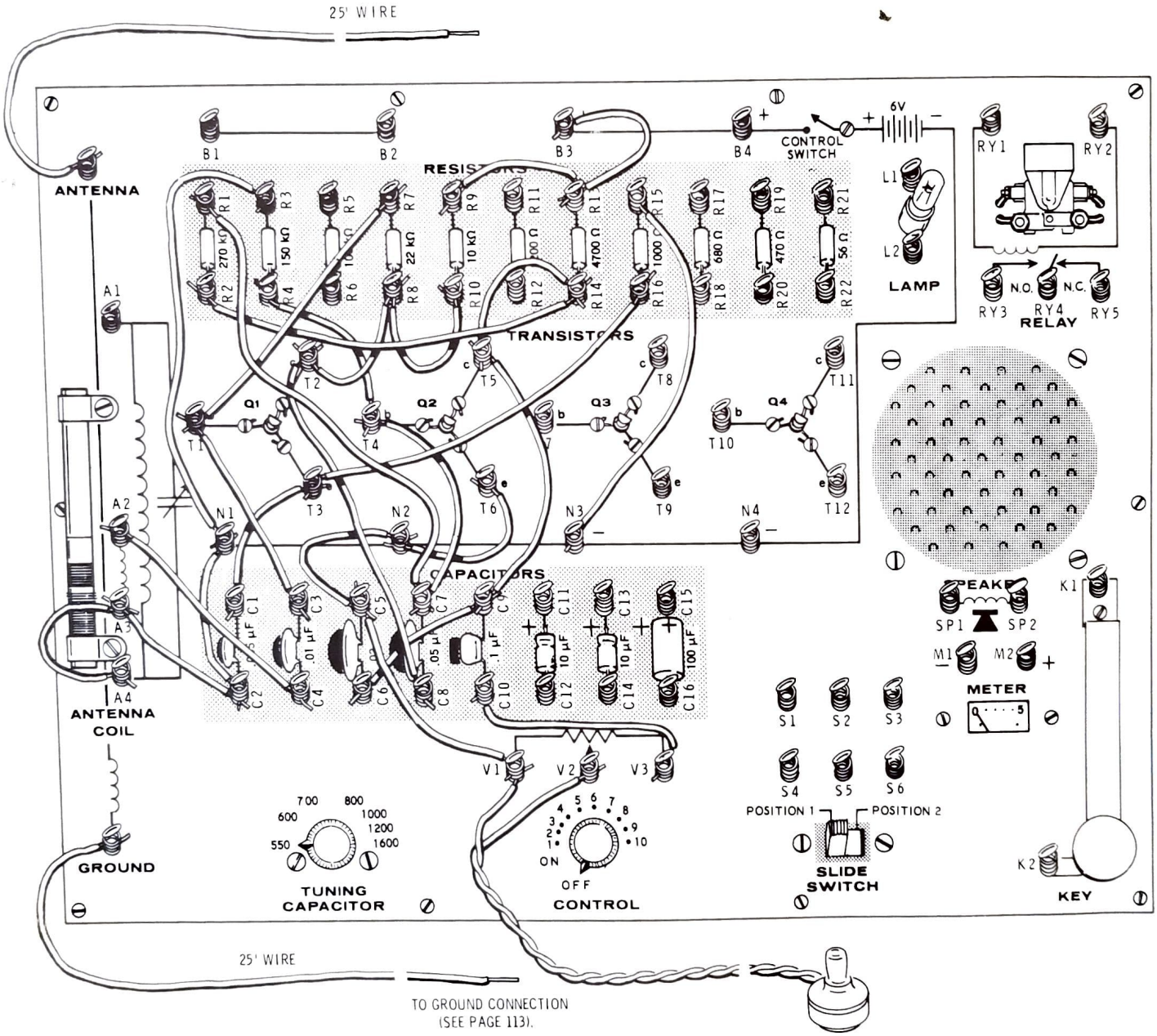
Sound Level Meter



EXPERIMENT 26
Two-Transistor Receiver

This Two-Transistor Receiver will receive local radio stations.

NOTE: AM radio Receivers are built in Experiments 26, 27, and 28. The simplest Receiver is in Experiment 26. Then, circuits are added in each Experiment until the largest Receiver is built in Experiment 28.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
THIRTEEN 3" BLACK*	R4	T4	
*	T2	R8	
*	R8	R10	
*	R9	R13	
	R13	B3	
*	N1	C2	
*	A4	A3	
*	A3	C2	
*	C5	N2	
*	N2	T6	
*	T5	R14	
*	C9	C6	
*	C1	T3	
SIX 4" BROWN *	V1	C5	
*	T1	C3	
*	T4	C7	
*	T5	C9	
*	C10	V3	
*	A2	C4	
SIX 6" RED *	R2	R14	
*	R3	N1	
*	R15	N3	
*	R7	T1	
*	T2	C8	
*	T3	R16	
ONE 8" ORANGE *	R1	C7	
EARPHONE	V2	V1	
25' WHITE *	SEE "ANTENNA		
25' WHITE-BLUE *	CONSIDERATIONS"		

*NOTE: Wires marked with an asterisk (*) are used in Experiments 26, 27, 28, and 29. Leave these wires in place, and remove only the other wires, if you decide to change from this circuit to Experiment 27, 28 or 29.

ANTENNA CONSIDERATIONS

ANTENNAS

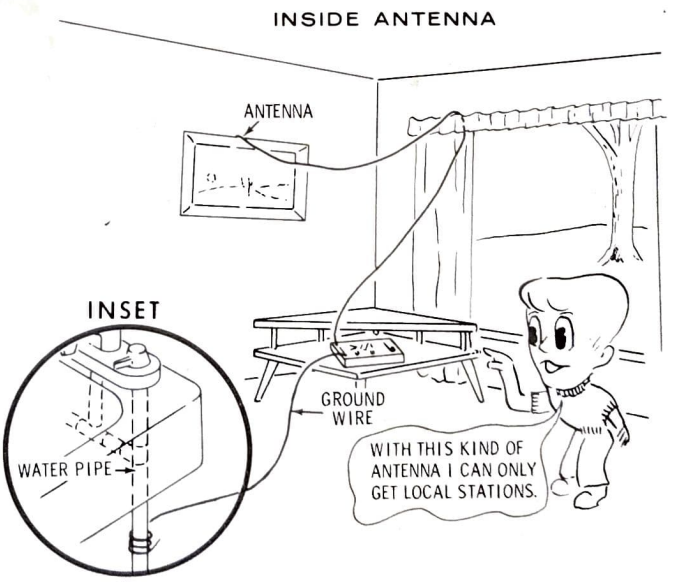
Each radio receiver must have an antenna, but the type of antenna it needs depends on where you live. If you live in a city near strong stations, the Antenna Coil itself may be all you need. (This type of antenna is used in most small radios.) If you live where all stations will be weak, you will probably need to use one of the 25 foot wires as a long wire antenna. Refer to the illustration and to the directions below for Inside and Outside Long Wire Antennas.

Sometimes it is best to experiment to see which type of antenna will bring in the most, clear stations. Often, connecting an antenna wire to a bedspring, metal lamp base, or a TV antenna wire will work very well.

Inside Long Wire Antenna

NOTE: An inside antenna will not work well inside a metal building. Radio waves will not go through the metal.

( ) Connect one end of a 25 foot wire to the ANTENNA connector spring. Stretch out the wire and run it around the room.



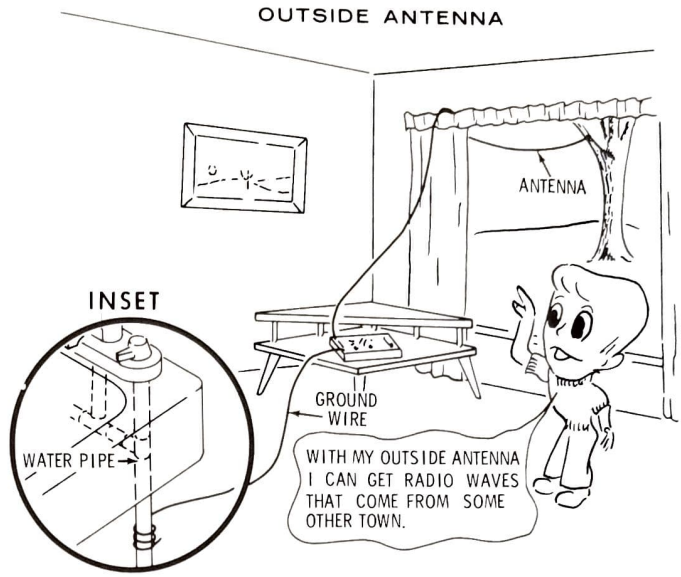
Outside Long Wire Antenna

( ) Connect one end of a 25' wire to the ANTENNA connector spring.

( ) Run this wire out the window and up as high as you can to a nearby tree or some other object.

( ) Tie the end of this wire to the tree. Be very careful that the wire's insulation is not broken or torn at the window or tree.

CAUTION: Do not run the antenna near power lines, and do not connect it to a metal post.



GROUND CONNECTIONS

Radio stations connect their signals to an antenna and to the ground. Therefore, a ground connection at your receiver will help you receive weaker stations.

( ) Connect a 25' wire to the GROUND connector spring on the Workshop.

( ) Remove 6" of insulation from the other end of this wire.

( ) Connect this bared end of the 25' wire to a cold water pipe or faucet. (The metal in the pipes connect to the ground outside your home.)

NOTE: Often, you may find that if the local stations are too strong, your receiver will work better when the ground is disconnected. The sound would get quieter and you would be able to tune in more stations. Experimenting will often show you how to get the best results.

OPERATION

NOTE: Radio waves usually travel farther at night. Therefore, you can usually tune in more stations at night.

( ) Complete your ANTENNA and GROUND connections. Use one of the antenna types described above.

( ) Place the Earphone in your ear.

( ) Turn the CONTROL clockwise until the switch clicks ON. Adjust the CONTROL to a comfortable listening level.

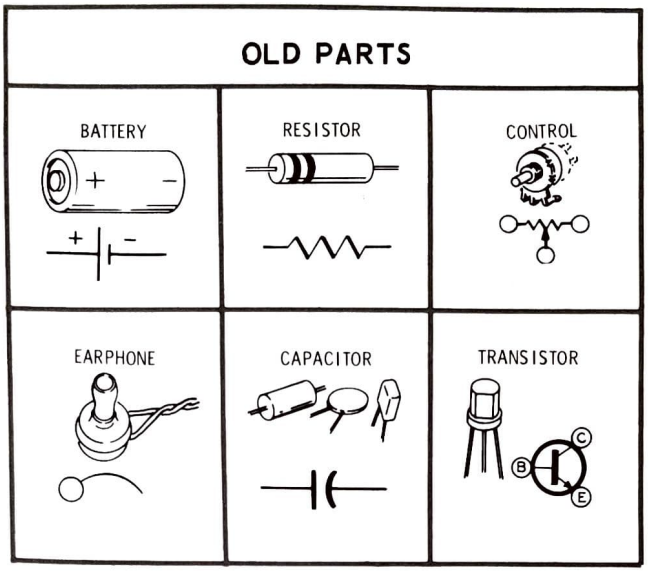
NOTE: If there are no radio stations in your area, you may not be able to tune in any stations with this Two-Transistor Receiver.

( ) Turn the TUNING CAPACITOR knob very slowly until you hear a radio station.

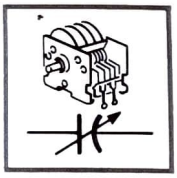
( ) See how many stations you can tune in and identify.

( ) Turn off the CONTROL when you are not using the Receiver.

PARTS



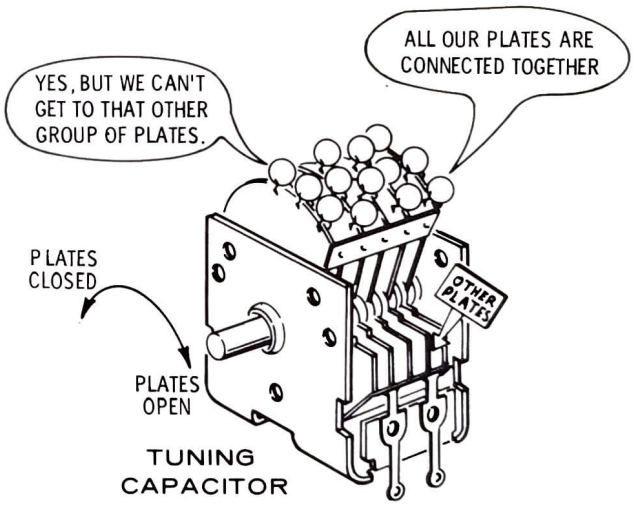
NEW PARTS

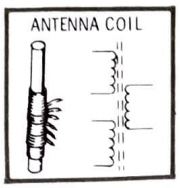


TUNING CAPACITOR - This capacitor works just like the other capacitors (see Page 54), except that its electrical size can be changed.

Instead of the two single plates, the tuning capacitor has two groups of plates. Each group has several plates, all connected to each other. Electrons cannot get from one group of plates to the other group. (Groups of plates do not touch each other.)

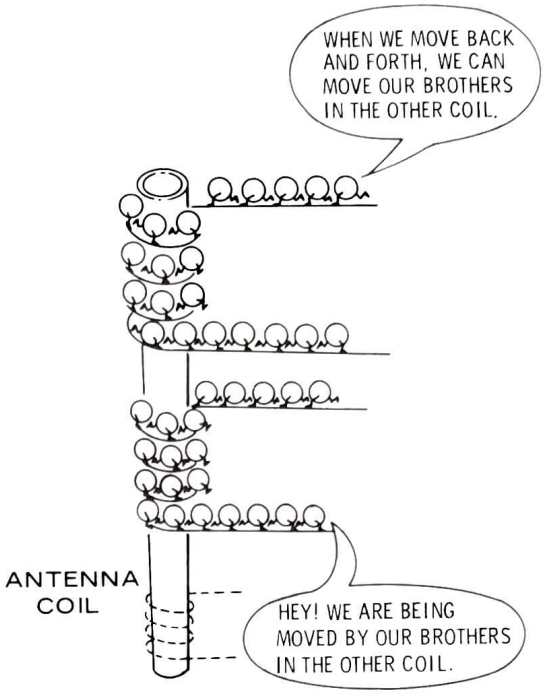
This capacitor's electrical size is largest when the plates are fully closed. Its electrical size is smallest when the plates are fully open.





ANTENNA COIL - A coil is made of many turns of fine wire. This Antenna Coil actually has three separate coils wrapped around a ferrite (an iron compound) rod.

A signal current from the antenna goes thru one of these coils to ground. This signal causes magnetism to build up around the coil, and the magnetism makes signal currents (just like the original) go thru the other coils, and from there to the first transistor.



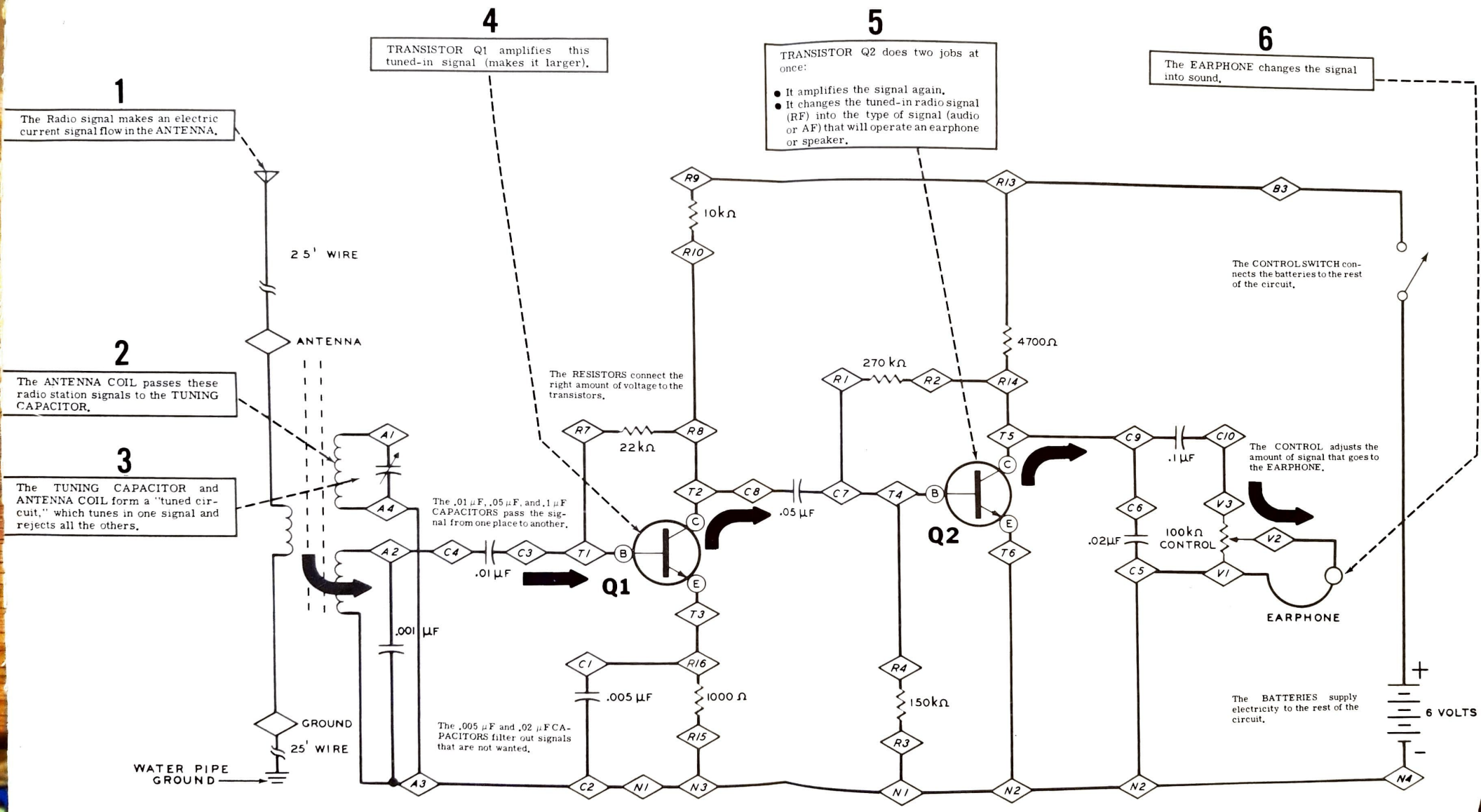
THINGS TO DO AFTER THE EXPERIMENT

Try listening to a radio station with the ground wire connected and with the ground wire disconnected. See if there is any difference. Try connecting and disconnecting the antenna to see if that makes a difference.

Disconnect the earphone. Then connect an 8" wire from V1 to SP1 and another 8" wire from V2 to SP2. Turn the CONTROL fully clockwise. Note that the volume in the speaker will not get very loud. An amplifier circuit will be added in the next two Experiments to give the Speaker more volume.

WHAT HAPPENS IN THE CIRCUIT

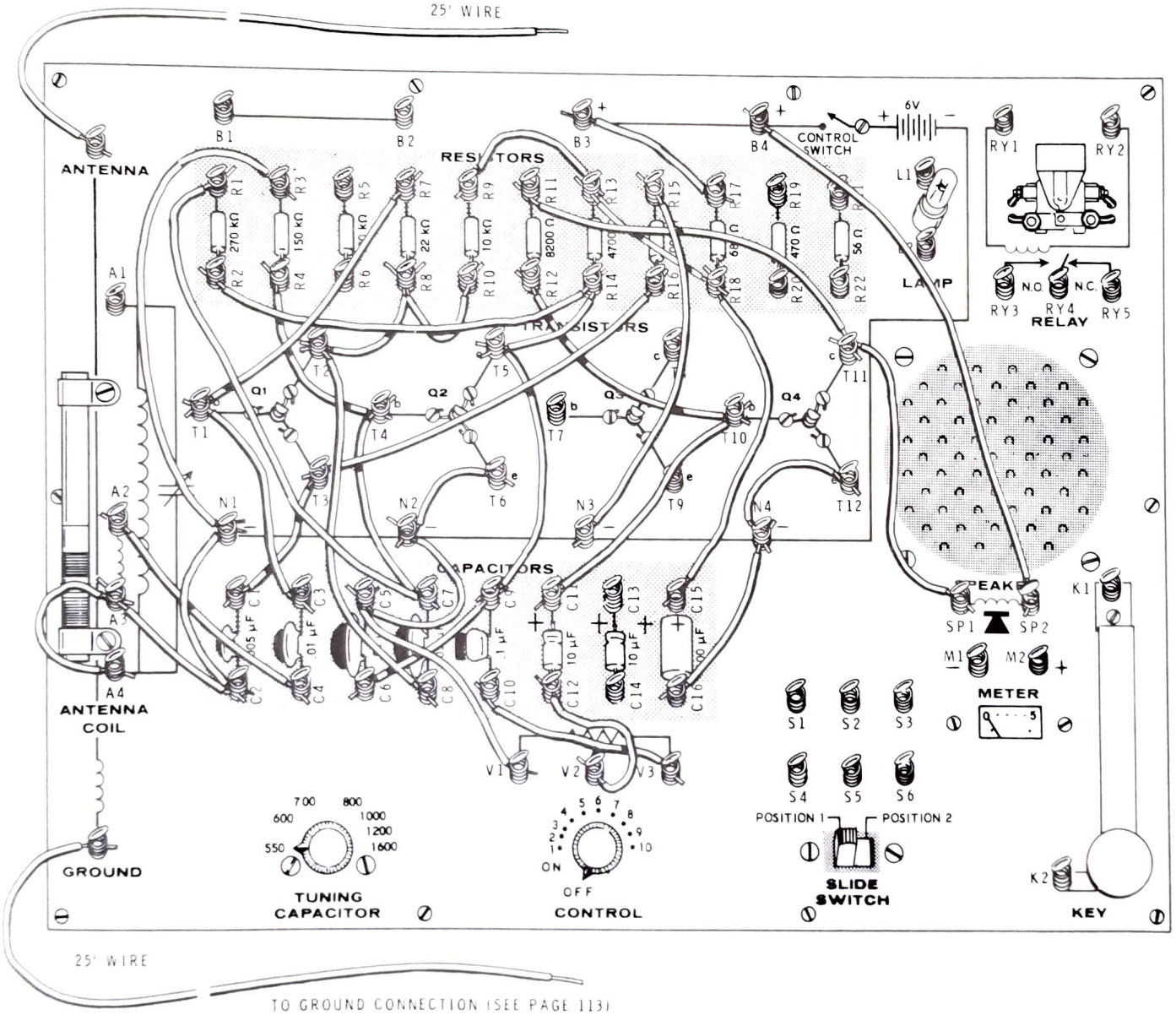
Two-Transistor Receiver



EXPERIMENT 27
Three-Transistor Receiver

This Three-Transistor Receiver is almost the same as the Two-Transistor Receiver, except that a third transistor is added so the Speaker can be used instead of the earphone.

NOTE: AM radio Receivers are built in Experiments 26, 27, and 28. The simplest Receiver is in Experiment 26. Then, circuits are added in each Experiment until the largest Receiver is built in Experiment 28.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
SEVENTEEN 3" BLACK *	R4	T4	
*	T2	R8	
*	R8	R10	
*	R9	R13	
	R13	R18	
	B3	R17	
*	N1	C2	
*	A4	A3	
*	A3	C2	
*	C5	N2	
*	N2	T6	
	T12	N4	C16
*	T5	R14	
*	C9	C6	
	V2	C12	
*	C1	T3	
NINE 4" BROWN *	V1	C5	
*	T1	C3	
*	T4	C7	
*	T5	C9	
*	C10	V3	
	R12	T10	C11
	T11	SP1	
*	A2	C4	
EIGHT 6" RED *	R2	R14	
*	R3	N1	
*	R15	N3	
*	R7	T1	
*	T2	C8	
*	T3	R16	
	R11	T11	
	R18	C15	
ONE 8" ORANGE *	R1	C7	
ONE 10" YELLOW	B4	SP2	
25' WHITE *	SEE "ANTENNA CONSIDERATIONS" ON PAGE 113		
25' WHITE-BLUE *			

*NOTE: Wires marked with an asterisk (*) are used in Experiments 26, 27, 28, and 29. Leave these wires in place, and remove only the other wires, if you decide to change from this circuit to Experiment 26, 28, or 29.

OPERATION

( ) Refer to the "Antenna Considerations" on Page 113. Then complete the ANTENNA and GROUND connections to your Workshop.

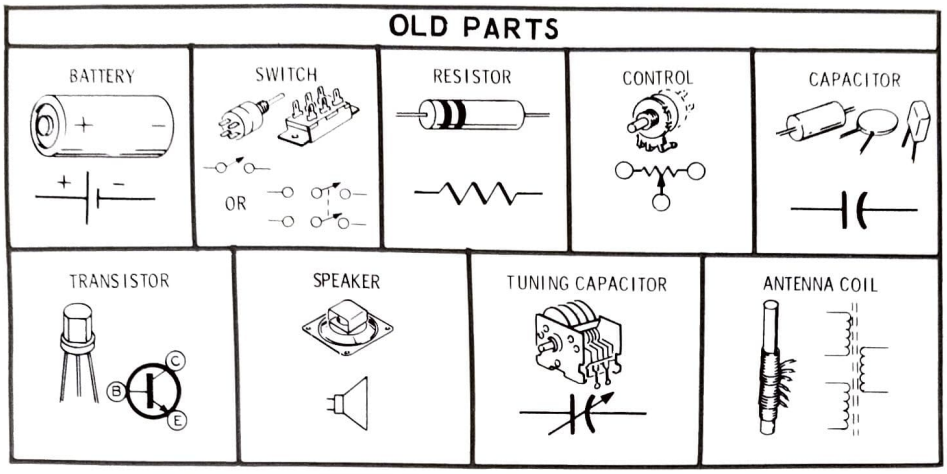
NOTE: Radio waves usually travel farther at night. Therefore, you can usually tune in more stations at night.

( ) Turn the CONTROL clockwise until the switch clicks ON. Adjust the CONTROL to a comfortable listening level.

( ) Turn the TUNING CAPACITOR knob very slowly until you hear a radio station.

( ) Turn off the CONTROL when you are not using the Receiver.

PARTS



THINGS TO DO AFTER THE EXPERIMENT

Try listening to a radio station with the ground wire connected and then disconnected. See if you notice a difference. Then try the same thing with the antenna wire.

Locate and count the number of radio stations you can receive during the day. Then see how many more radio stations you can receive at night.

Make a list of all the stations you can receive. Write down the TUNING CAPACITOR knob position and the call letters for each station.

If you are not using the 25' wires, you can connect the Remote Station to the Workshop in the following manner. Then either the remote speaker or the Workshop speaker can be used.

( ) Remove the 4" wire from T11 to SP1.

( ) Connect a 6" wire from T11 to SP2.

( ) Connect a 3" wire from S3 to SP1.

( ) Connect a 25' wire from SP3 on the Remote Station to SP2 on the Workshop.

( ) Connect a 25' wire from COM on the Remote Station to S1 on the Workshop.

Now when the SLIDE SWITCH is in Position 2, the Workshop speaker will operate. When the SLIDE SWITCH is in Position 1, the Remote Station will operate.

WHAT HAPPENS IN THE CIRCUIT

Three-Transistor Receiver

1 2 3 4 5

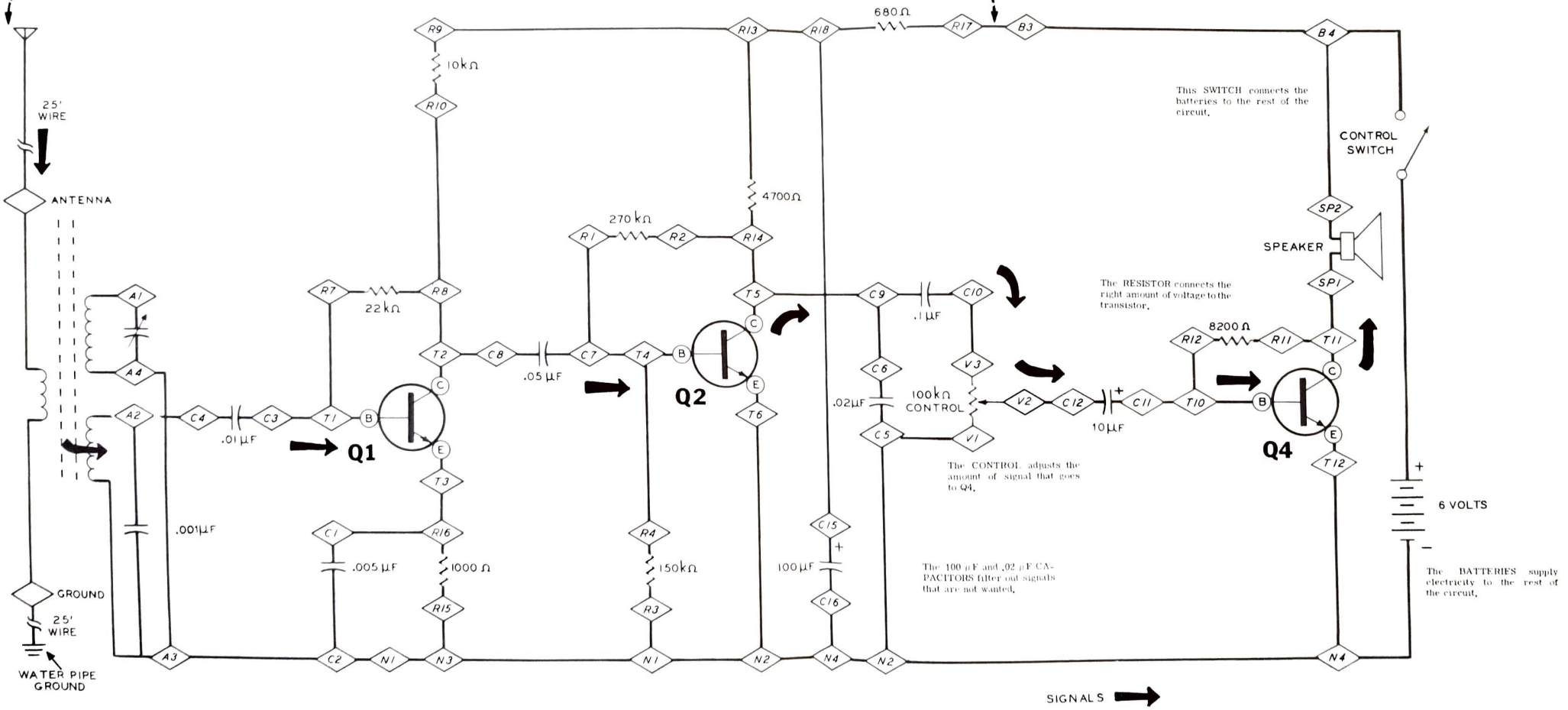
NOTE: This section was described in EXPERIMENT 26.

6

From the CONTROL, the signal passes thru the 10 μF CAPACITOR to Q4. Here it is amplified again and coupled to the SPEAKER.

7

The SPEAKER changes the signal into sound.

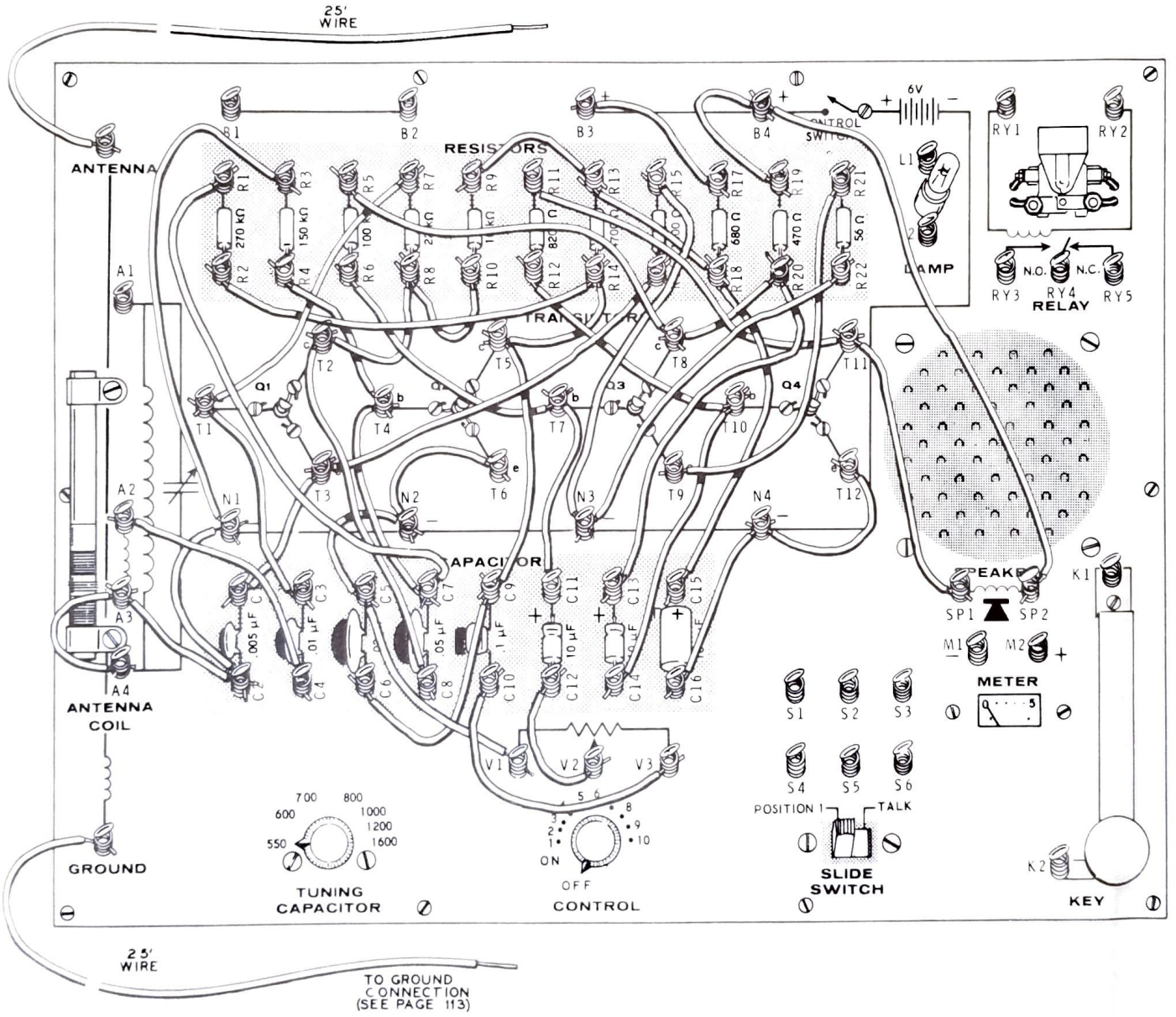


EXPERIMENT 28

Four-Transistor Receiver

This Four-Transistor Receiver is almost the same as the Three-Transistor Receiver, except that a fourth transistor is added to increase the sound from the speaker.

NOTE: AM radio Receivers are built in Experiments 26, 27, and 28. The simplest Receiver is in Experiment 26. Then, circuits are added in each Experiment until the largest Receiver is built in this Experiment.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
NINETEEN 3" BLACK *	R4	T4	
*	T2	R8	
*	R8	R10	
*	R9	R13	
	R13	R18	
	R19	B4	
	B3	R17	
*	N1	C2	
*	A4	A3	
*	A3	C2	
*	C5	N2	
*	N2	T6	
	T12	N4	C16
	C12	V2	
*	T5	R14	
	T8	R20	
*	C9	C6	
*	C1	T3	
TEN 4" BROWN *	V1	C5	
	R6	T7	C11
*	T1	C3	
*	T4	C7	
*	T5	C9	
*	C10	V3	
	R12	T10	
	T11	SP1	
*	A2	C4	
THIRTEEN 6" RED *	R2	R14	
*	R3	N1	
	R15	N3	
	R5	T8	
*	R7	T1	
*	T2	C8	
*	T3	R16	
	R11	T11	
	T10	C14	
	R18	C15	
	R20	C13	
	R21	T9	
	R22	N3	
ONE 8" ORANGE *	R1	C7	
ONE 10" YELLOW	B4	SP2	
25' WHITE *	SEE "ANTENNA CONSIDERATIONS" ON PAGE 113.		
25' WHITE - BLUE *			

OPERATION

( ) Refer to the "Antenna Considerations" on Page 113. Then complete the ANTENNA and GROUND connections to your Workshop.

NOTE: Radio waves usually travel farther at night. Therefore, you can usually tune in more stations at night.

( ) Turn the CONTROL clockwise until the switch clicks ON. Adjust the CONTROL to a comfortable listening level.

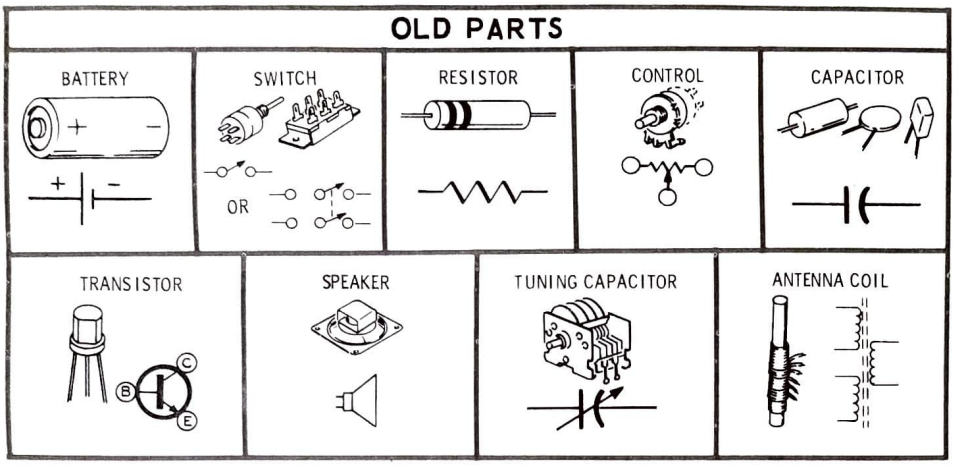
( ) Turn the TUNING CAPACITOR knob until you hear a radio station.

( ) After tuning in a radio station, you may have to increase or decrease the volume.

( ) Turn off the CONTROL when you are not using the Receiver.

*NOTE: Wires marked with an asterisk (*) are used in Experiments 26, 27, 28, and 29. Leave these wires in place, and remove only the other wires, if you decide to change from this circuit to Experiment 26, 27, or 29.

PARTS



THINGS TO DO AFTER THE EXPERIMENT

Locate and count the number of stations you can receive. Write down the TUNING CAPACITOR knob position and the call letters for each station. Then compare this with the list of stations you made at the end of Experiment 27.

Amplifiers make things larger. In the following steps you will operate the Radio with and without amplifier transistor Q3.

( ) Tune in a station on the Receiver.

( ) Disconnect the 6" red wire from C13.

( ) Connect one end of a 4" brown wire to C12.

( ) Touch the other end of the 4" brown wire to C13. Q3 is now bypassed and not being used. Notice that the sound is not as loud as it was before.

( ) Disconnect the 4" brown wire from C13.

( ) Reconnect the 6" red wire to C13. Q3 is connected up again.

If you are not using the 25' wires, you can connect the Remote Station to the Workshop in the following manner. Then either the remote speaker or the Workshop speaker can be used.

( ) Remove the 4" brown wire from T11 to SP1.

( ) Connect a 6" red wire from T11 to S2.

( ) Connect a 3" black wire from S3 to SP1.

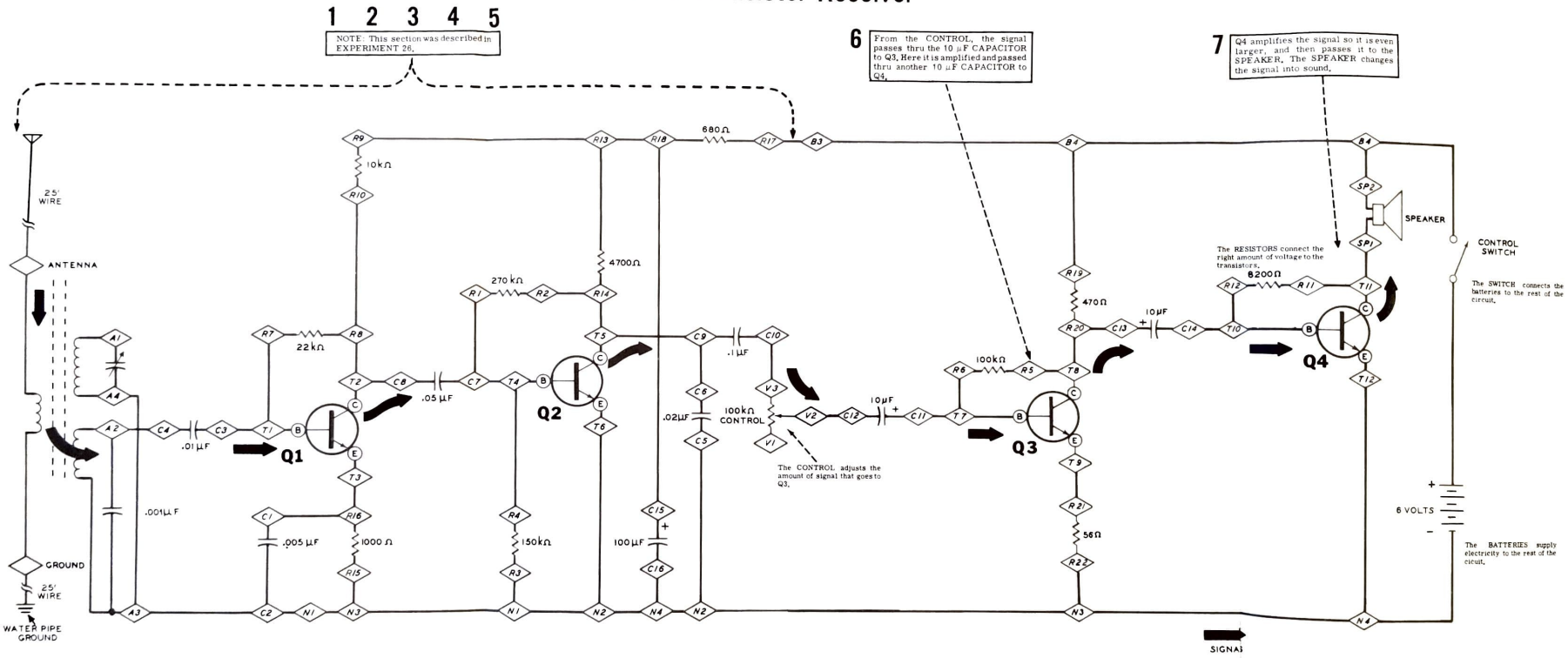
( ) Connect a 25' wire from SP3 on the Remote Station to SP2 on the Workshop.

( ) Connect a 25' wire from COM on the Remote Station to S1 on the Workshop.

Now, when the SLIDE SWITCH is in Position 2, the Workshop speaker will operate. When the SLIDE SWITCH is in Position 1, the Remote Station will operate.

WHAT HAPPENS IN THE CIRCUIT

Four-Transistor Receiver



Automatic Radio

1 2 3 4 5

This section was described in EXPERIMENT 26.

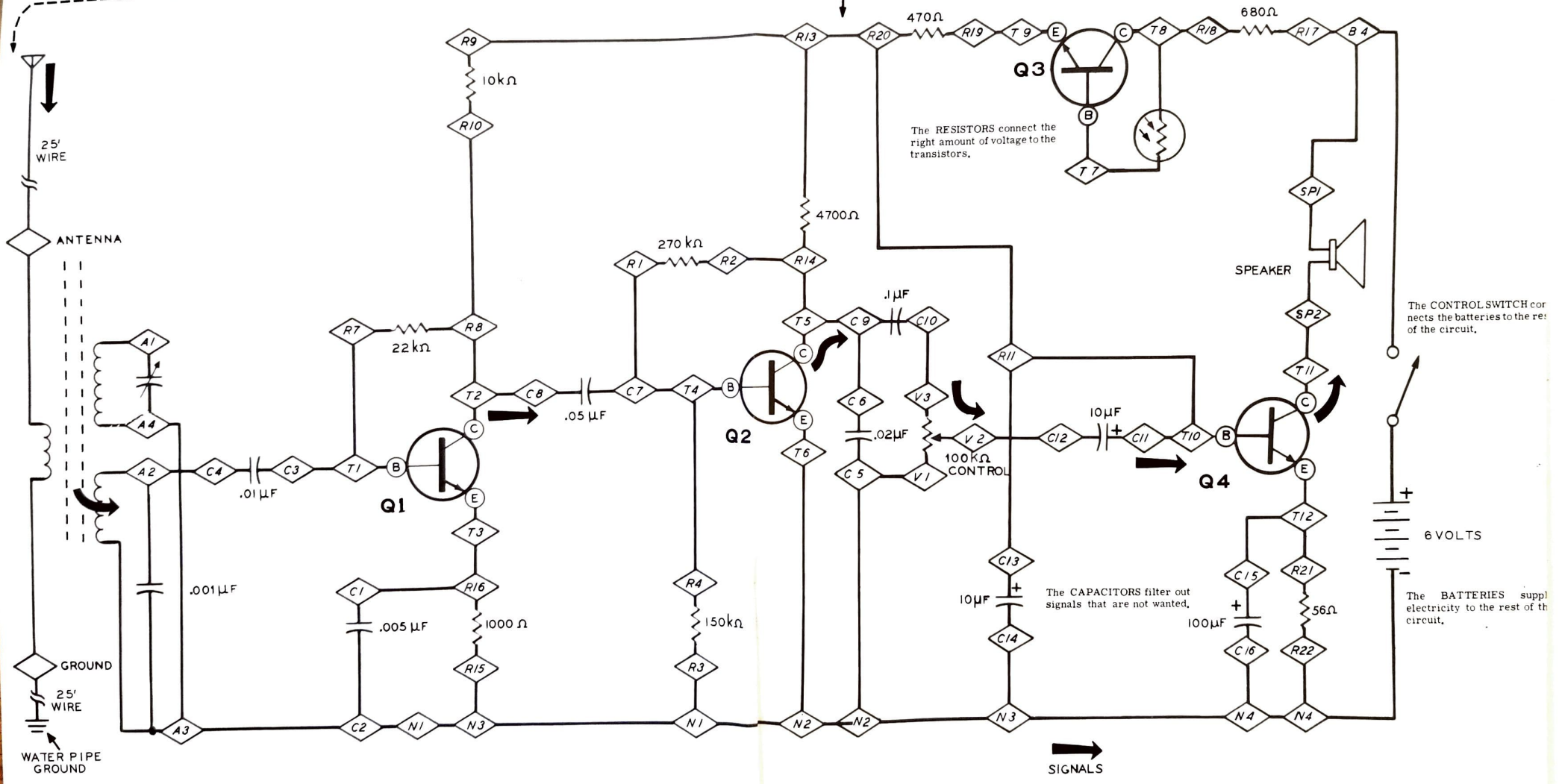
6

With the LDR in the dark, not much current can pass thru Q3.

With more light, the LDR turns Q3 on harder and more current goes thru it (Q3). This makes more battery voltage available at Q1 and Q2 so they can amplify more and make a larger signal.

7

From the CONTROL, the signal passes thru the 10 μF capacitor to Q4. Q4 amplifies the signal and couples it to the SPEAKER, which changes it to sound.



The RESISTORS connect the right amount of voltage to the transistors.

The CAPACITORS filter out signals that are not wanted.

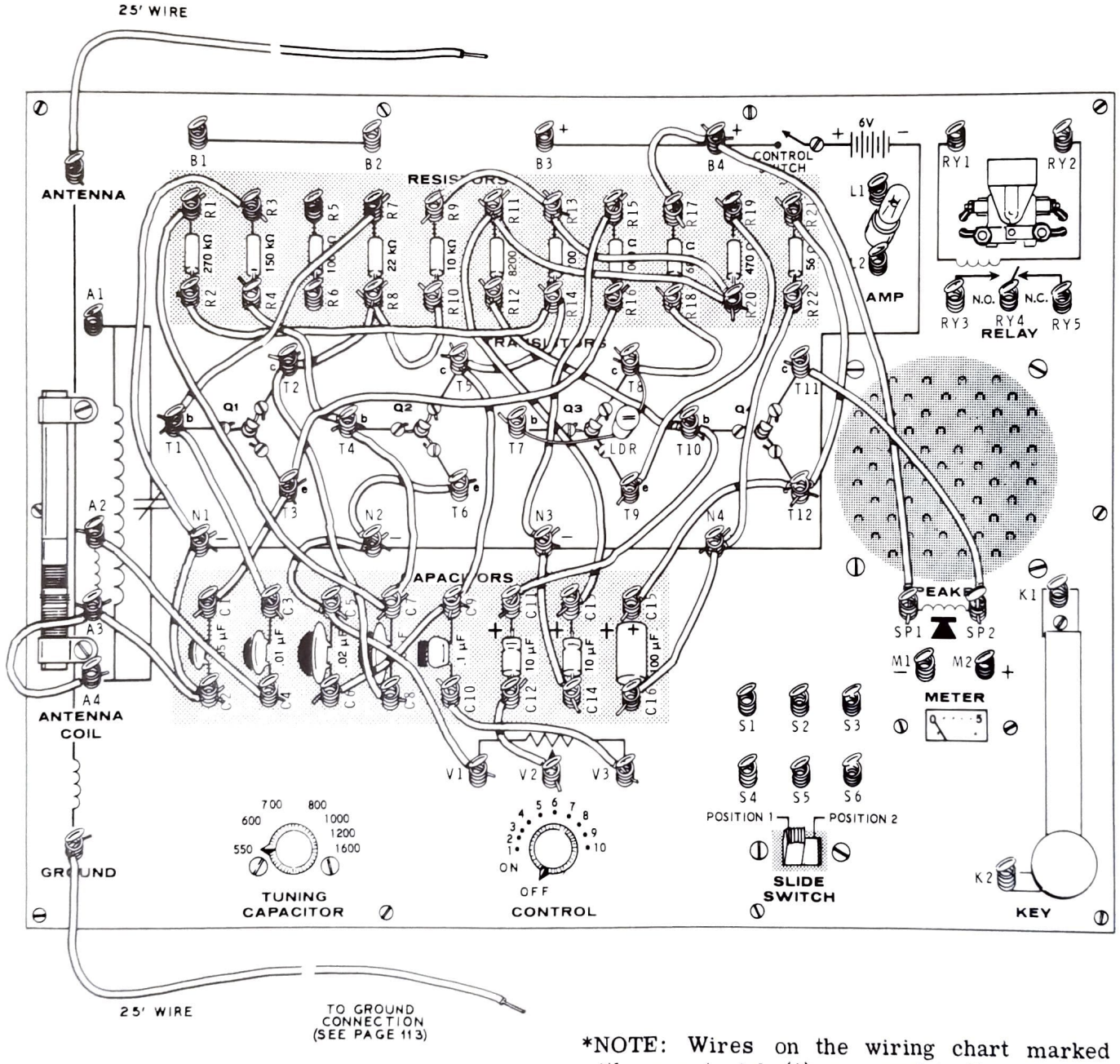
The CONTROL SWITCH connects the batteries to the rest of the circuit.

The BATTERIES supply electricity to the rest of the circuit.

EXPERIMENT 29

Automatic Radio

In this Experiment you will build a Radio where the volume will depend on the amount of light in the room.



*NOTE: Wires on the wiring chart marked with an asterisk (*) are used in Experiments 26, 27, 28, and 29. Leave these wires in place, and remove only the other wires, if you decide to change from this circuit to Experiment 26, 27, or 28.

WIRING CHART			
USE	FROM	TO	
		FROM	TO
SEVENTEEN 3" BLACK	* R4	T4	
*	T2	R8	
*	R8	R10	
*	R9	R13	
*	R14	T5	
	R18	T8	
*	C5	N2	
*	N2	T6	
*	A4	A3	
*	A3	C2	
*	C2	N1	
*	C6	C9	
	N3	C14	
	C12	V2	
	C16	N4	
	B4	R17	
*	C1	T3	
TEN 4" BROWN	C15	T12	
	R13	R20	
	R12	T10	
*	T5	C9	
*	T4	C7	
*	C10	V3	
*	T1	C3	
*	A2	C4	
*	V1	C5	
	C11	T10	
TWELVE 6" RED *	R15	N3	
*	T1	R7	
	R21	T12	
*	R2	R14	
*	R16	T3	
*	T2	C8	
	C13	R11	R20
	T9	R19	
	T11	SP2	
	R22	N4	
*	R3	N1	
TWO 8" ORANGE	B4	SP1	
*	R1	C7	
LDR	T7	T8	
25' WHITE *	SEE "ANTENNA CONSIDERATIONS" ON PAGE 113.		
25' WHITE-BLUE *			

OPERATION

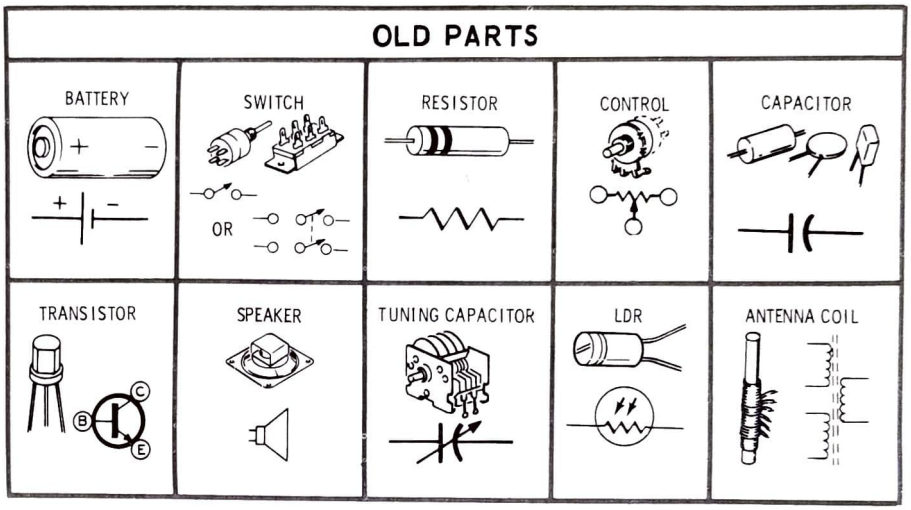
( ) Refer to the "Antenna Considerations" on Page 113. Then complete the ANTENNA and GROUND connections to your Workshop.

( ) Turn the CONTROL to ON, and then adjust it for a comfortable listening level.

( ) Tune in a station. Then move your hand back and forth over the LDR and notice the difference in volume.

( ) Turn off the CONTROL.

PARTS



WHAT HAPPENS IN THE CIRCUIT

See the fold-out from Page 126.

THINGS TO DO AFTER THE EXPERIMENT

( ) Connect a 3" black wire from B4 to L1.
( ) Connect a 6" red wire from L2 to K1.
( ) Connect an 8" orange wire from K2 to N4.

( ) Turn the CONTROL to ON, and then adjust it for a comfortable listening level.

( ) Dim the lights in the room and point the end of the LDR toward the Lamp.

( ) Push the KEY and see how the volume changes.

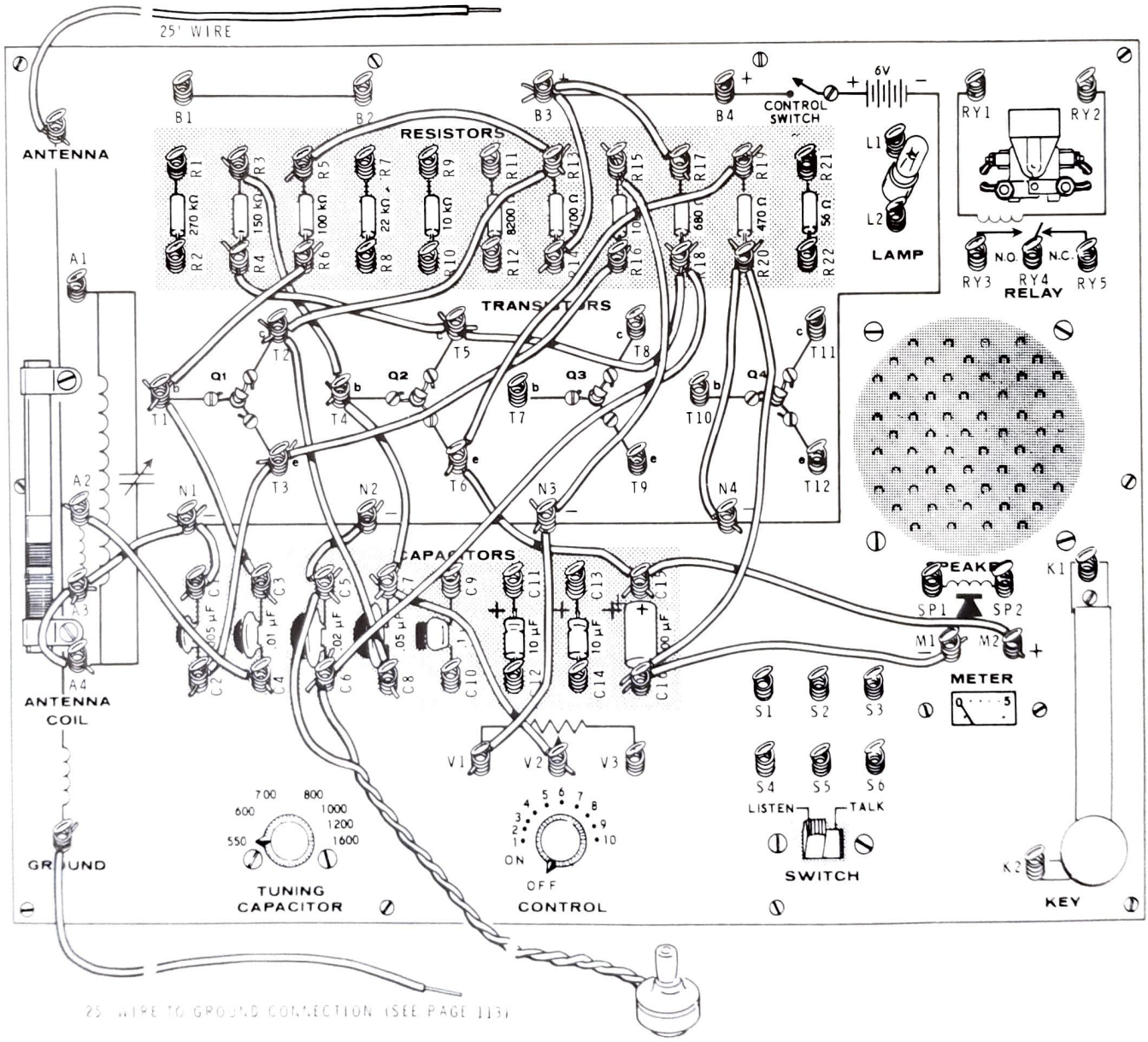
( ) Point the LDR away from the Lamp and press the KEY again.

( ) Turn off the CONTROL when you are not using the Radio.

EXPERIMENT 30

Field Strength Indicator

A Field Strength Indicator is used to measure the strength of a radio or television signal. Electronic Engineers use them to see how strong the signal is at various distances and directions from a broadcasting station. In this Experiment, you will build a simple Field Strength Indicator so you can see how they operate.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
SIX 3" BLACK	A4	A3	N1
	N1	C1	
	N2	C5	
	R17	B3	R14
TWELVE 4" BROWN	R5	R13	
	R6	T1	C3
	R4	T5	
	R3	T4	C7
	A2	C4	
	C7	V2	
	V1	N3	
	T6	C15	
	R2	N4	
	T3	C2	
SIX 6" RED	R13	T2	C8
	T3	R16	
	R15	N3	
	C15	M2	
	C16	M1	
TWO 8" ORANGE	R19	T6	
	R20	C16	
ONE 10" YELLOW	C6	R18	
EARPHONE	C5	C6	
25' WHITE 25' WHITE-BLUE	SEE "ANTENNA CONSIDERATIONS" ON PAGE 113.		

OPERATION

( ) Refer to the "Antenna Considerations" on Page 113. Then complete the ANTENNA and GROUND connections to your Workshop.

( ) Temporarily connect a 3" black wire from A2 to A3.

( ) Turn the CONTROL clockwise until the meter needle moves just above zero.

( ) Remove the 3" black wire that connects A2 to A3.

In the following steps the Meter will show the strength of each signal you can receive. Weak signals will be down near zero and strong signals will be near 5 on the Meter. If an extra strong signal makes the Meter indicate more than 5, disconnect the antenna or ground wire. This will make the signal weaker so you can measure it on the Meter.

In a professional Field Strength Meter, the meter indicates in a quantity called "microvolts" (millionths of a volt).

NOTE: The Earphone is only used in this Experiment to tune in stations so you can see how strong their signal is on the Meter. Do not be concerned if the sound is distorted.

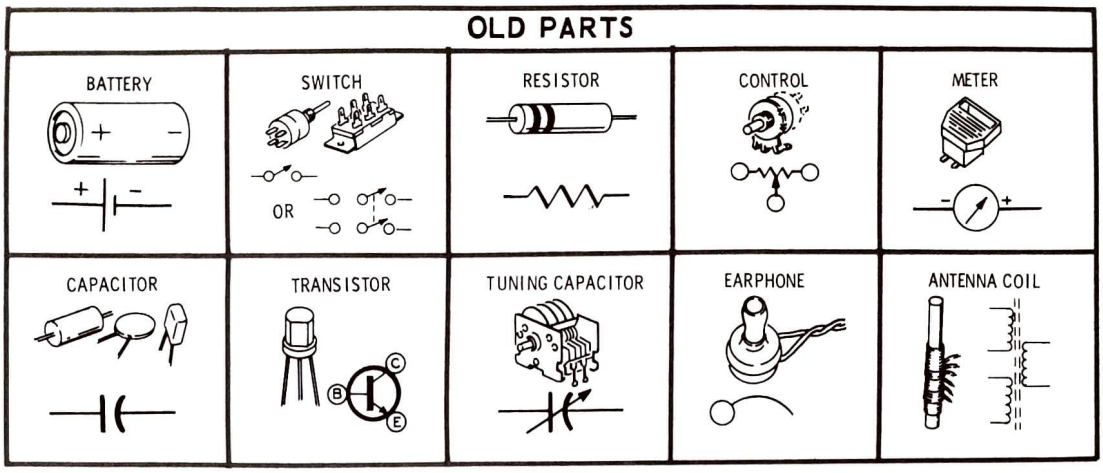
( ) Place the Earphone in your ear.

( ) Tune in the station you want to check. The Meter will show how strong the signal is.

( ) Now tune in each of the other stations you can receive. The Meter will show you which stations are stronger.

( ) Turn off the CONTROL when you complete the Experiment.

PARTS



THINGS TO DO AFTER THE EXPERIMENT

A tuning meter can also be used to tell you when a station is tuned in properly. The following steps will show you how this Field Strength Indicator may be used for this purpose.

( ) Turn the TUNING CAPACITOR fully counterclockwise.

( ) Take the Earphone out of your ear.

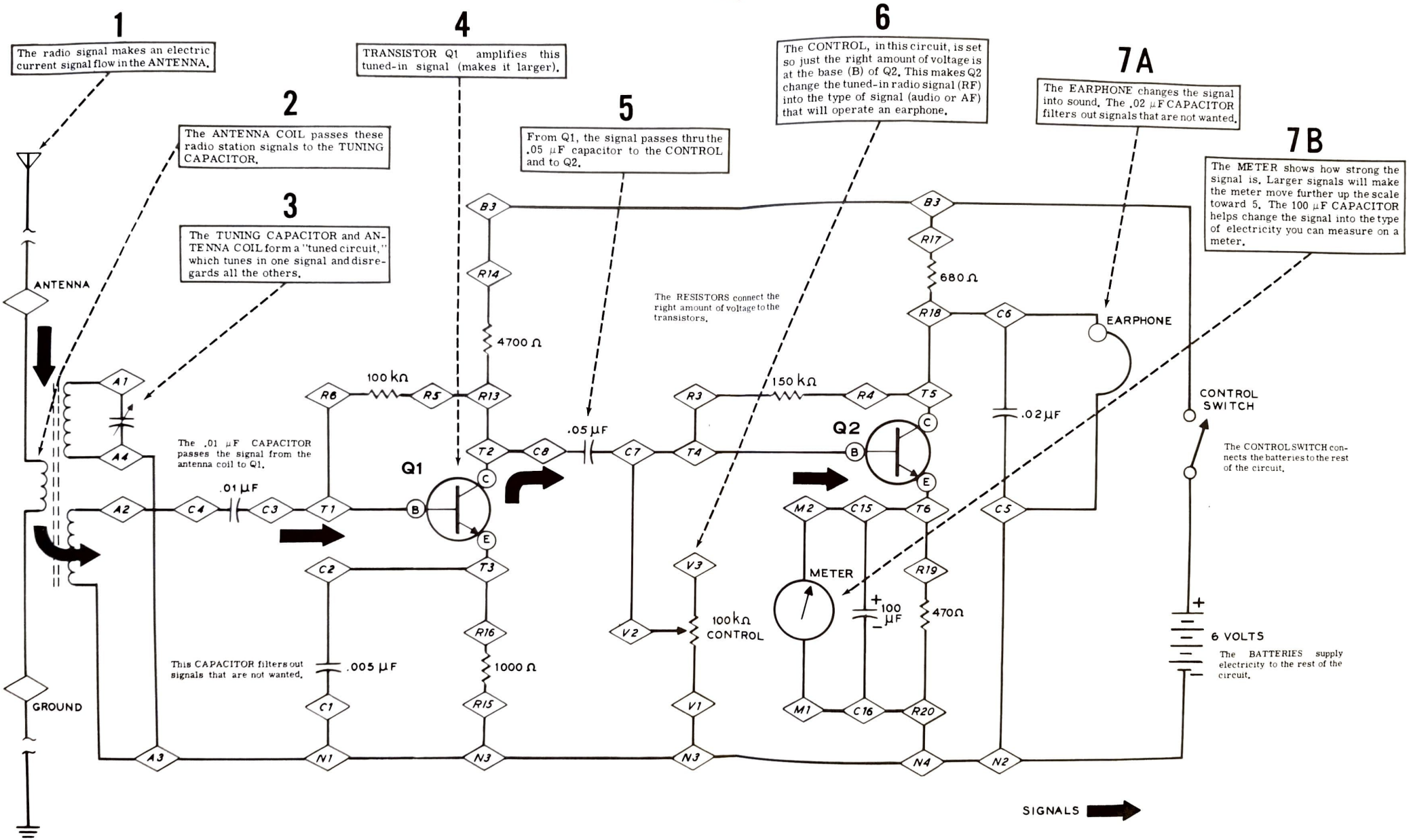
( ) Tune in a station using only the Meter by watching for the highest indication on the Meter.

( ) Now listen to the Earphone. You should hear a station.

Tuning meters help you tune in stations accurately. This accurate tuning is very important in FM stereo when you want your music to sound best.

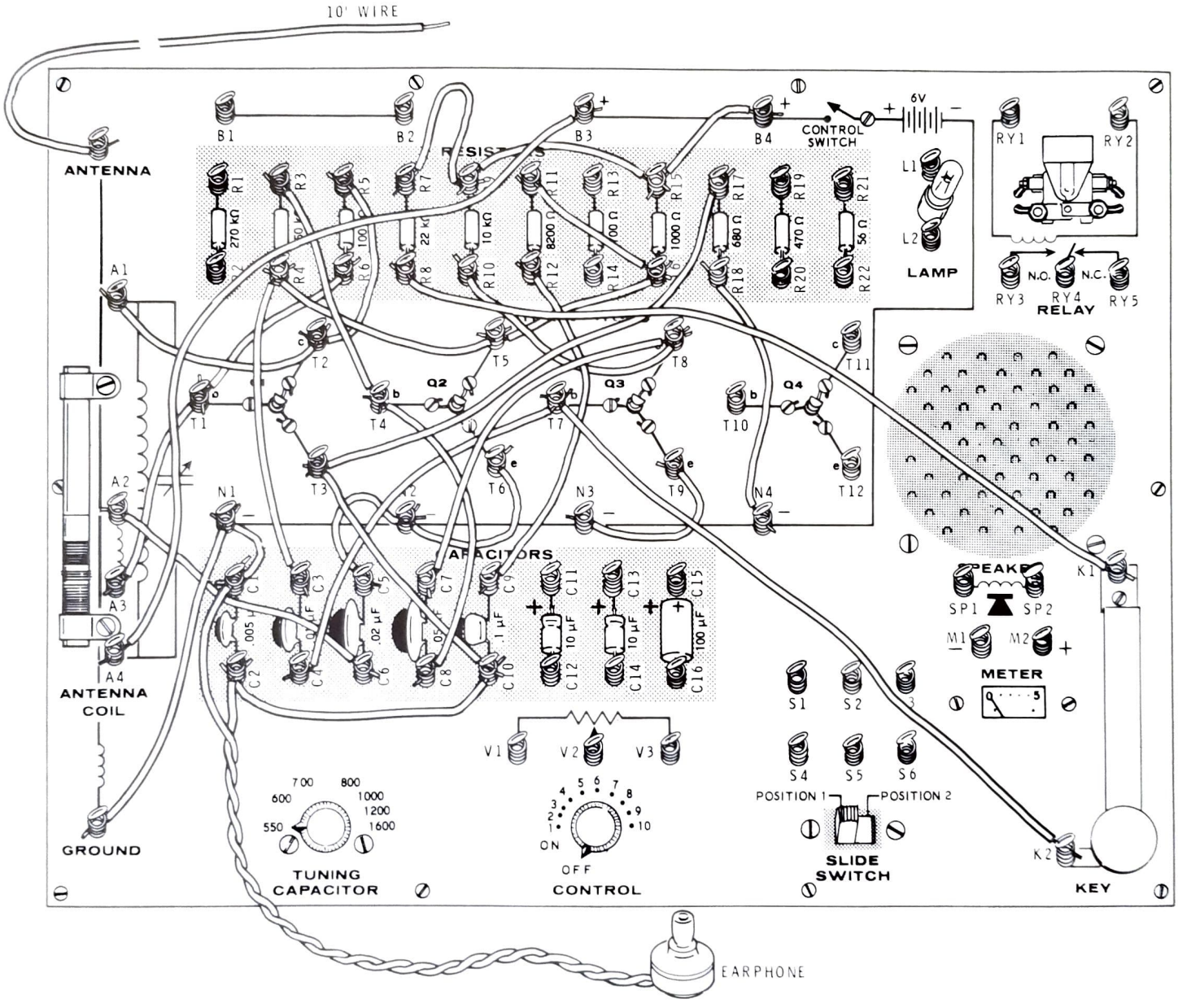
WHAT HAPPENS IN THE CIRCUIT

Field Strenth Indicator



EXPERIMENT 31
Code Transmitter

Use this Code Transmitter to learn the Morse Code (fold-out from Page 163) and to send signals that you can hear in your Radio.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
EIGHT 3" BLACK	T2	R5	
	R7	R9	
	R11	R16	T5
	R15	B4	
	T6	N2	C5
	N3	T9	
NINE 4" BROWN	A3	T1	R6
	A1	T2	
	R4	T5	
	R10	T8	
	R9	R15	
	R18	N4	
	R3	T4	
	C2	C10	
EIGHT 6" RED	A2	C6	
	R4	C3	
	C4	T7	
	T3	C10	
	T4	C8	
	R12	C9	
	T8	C7	
	N1	GROUND	
TWO 10" YELLOW	T3	R17	
	T7	K2	
TWO 12" BLACK	R8	K1	
	A4	B3	
EARPHONE	C1	C2	

OPERATION

NOTE: It is against government regulations to use a wire more than 10 feet long in the next step.

( ) Connect a wire less than 10 feet long to the ANTENNA spring.

( ) Place the unconnected end of this wire near an AM radio.

( ) Set your AM radio dial to where there is no station.

( ) Put the Earphone in your ear.

( ) Turn the CONTROL to ON and push the KEY. You should hear a tone in the Earphone.

( ) Hold the KEY down and adjust the TUNING CAPACITOR until you hear a tone from the radio.

( ) Move the radio and your Workshop away from each other. Your Code Transmitter is now ready for use.

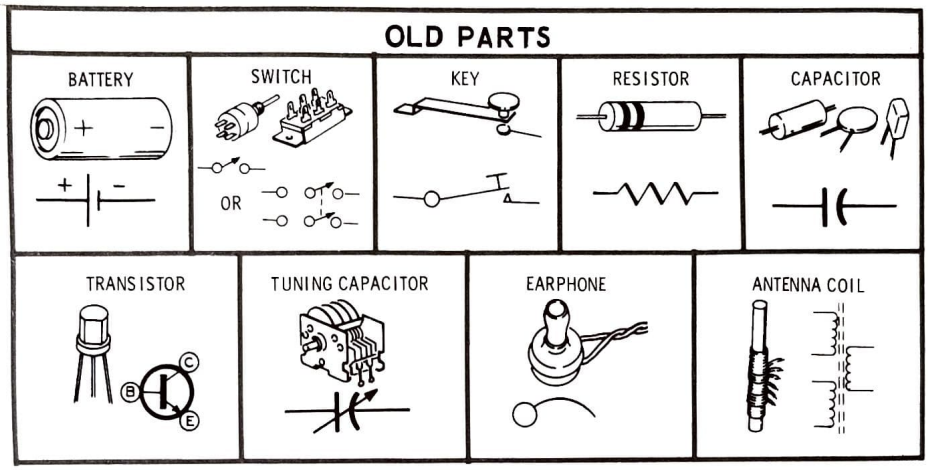
Refer to the Morse Code on fold-out from Page 163. To learn the code, practice sending and receiving letters and numbers with a friend. Try to learn just a few letters at a time; then go on to practice several new letters.

( ) Turn off the CONTROL when you complete the Experiment.

APPLICATIONS

Code transmitters are used in many forms. Airports send out coded signals that planes can use to locate that airport. Coded navigation signals are sent out that ships and planes can use to find out where they are at. Most ships at sea communicate with each other and with shore stations by using Morse Code. News services also communicate with newspapers and radio stations by using automatic code machines called "Teletype" machines.

PARTS



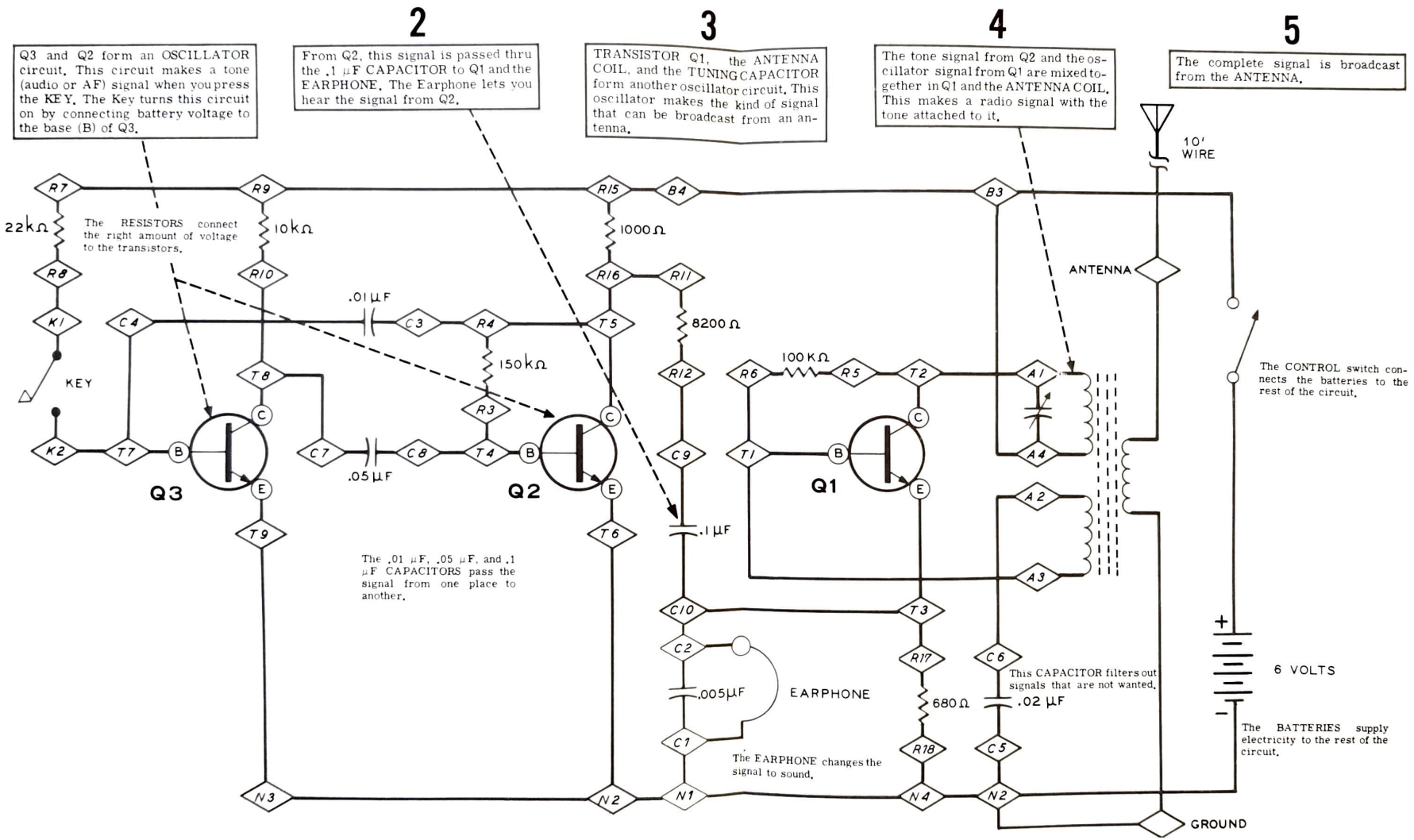
THINGS TO DO AFTER THE EXPERIMENT

( ) Disconnect the antenna wire from the ANTENNA terminal and reconnect it to A1.

( ) Now, starting at the low end of the radio dial (550 kHz), try to find the highest frequency at which you can transmit code to the radio. Notice that you can now transmit at a greater distance from the radio.

WHAT HAPPENS IN THE CIRCUIT

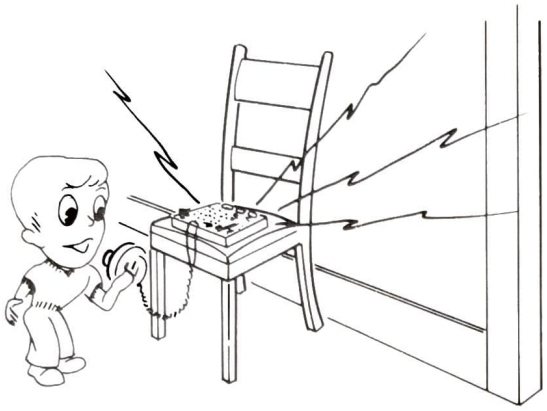
Code Transmitter

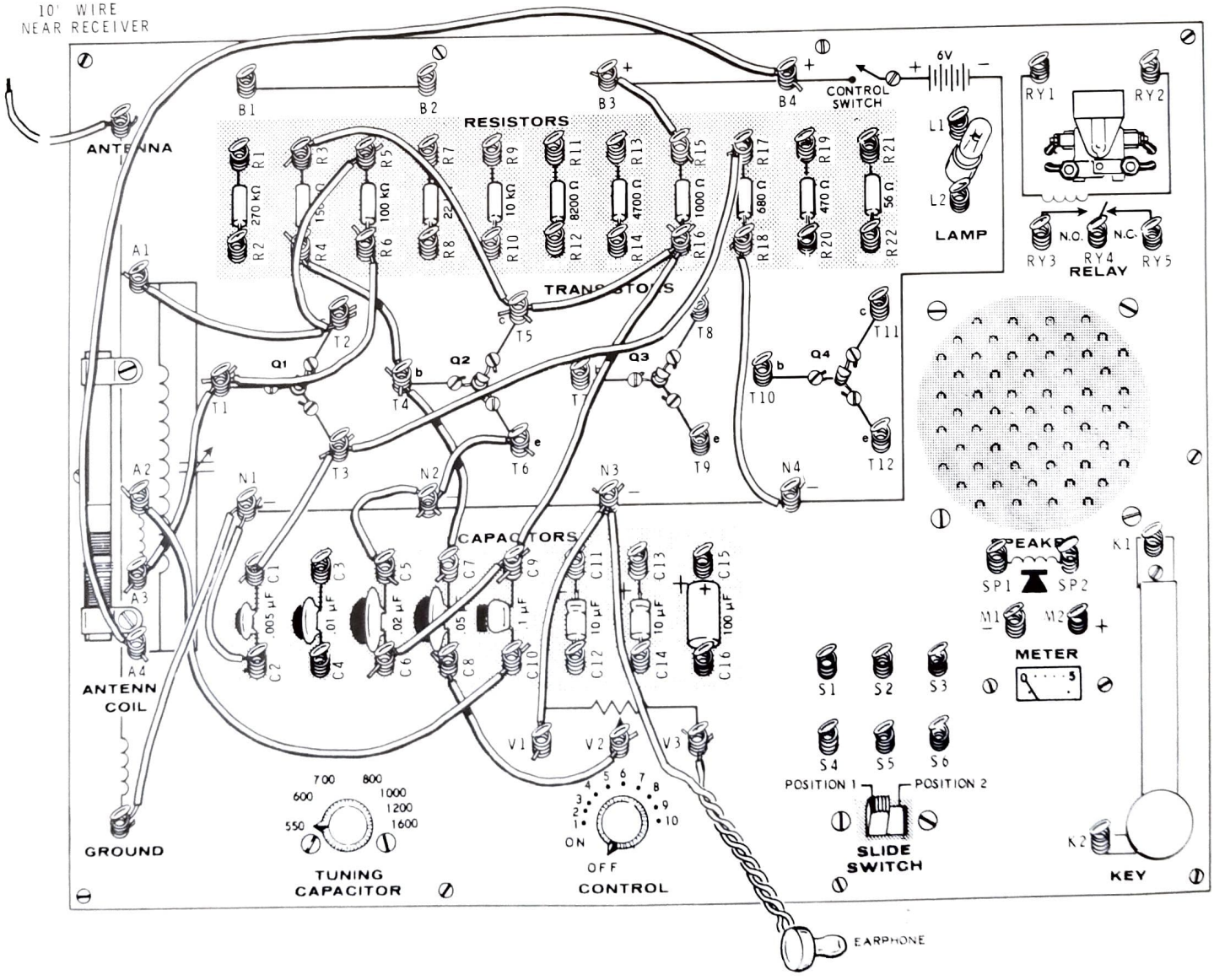


EXPERIMENT 32

Voice Transmitter

This Transmitter will change your voice signals into radio waves. Then you will be able to hear your voice on the radio.





WIRING CHART			
USE	FROM	TO	
		FROM	TO
NINE 3" BLACK	R4	T4	
	C5	N2	T6
	T5	R16	
	R15	B3	
	T2	R5	
	C6	C9	
	N1	C2	
	T3	C1	
SEVEN 4" BROWN	T4	C7	
	A1	T2	
	R6	T1	
	C8	V2	
	V1	N3	
	N4	R18	
	A3	T1	
THREE 6" RED	R3	T5	
	C9	R16	
	N1	GROUND	
ONE 8" ORANGE	A2	C10	
ONE 10" YELLOW	T3	R17	
ONE 14" BROWN	A4	B4	
EARPHONE	N3	V3	

OPERATION

ADJUSTING THE TRANSMITTER

NOTE: It is against government regulations to use a wire more than 10 feet long in the next step.

( ) Connect a wire less than 10 feet long to the ANTENNA spring.

( ) Place the unconnected end of the antenna wire near an AM radio.

( ) Set the radio dial to where there is no station near 600 (marked 60 or 6 on some radios) on the dial.

( ) Turn the CONTROL on the Workshop to ON.

( ) Tune the TUNING CAPACITOR until you hear a quiet spot (very little noise) on the radio.

( ) Adjust the CONTROL for clearest sound.

USING THE TRANSMITTER

( ) Move the radio and your Workshop away from each other.

( ) Talk into the Earphone and have someone listen to the radio.

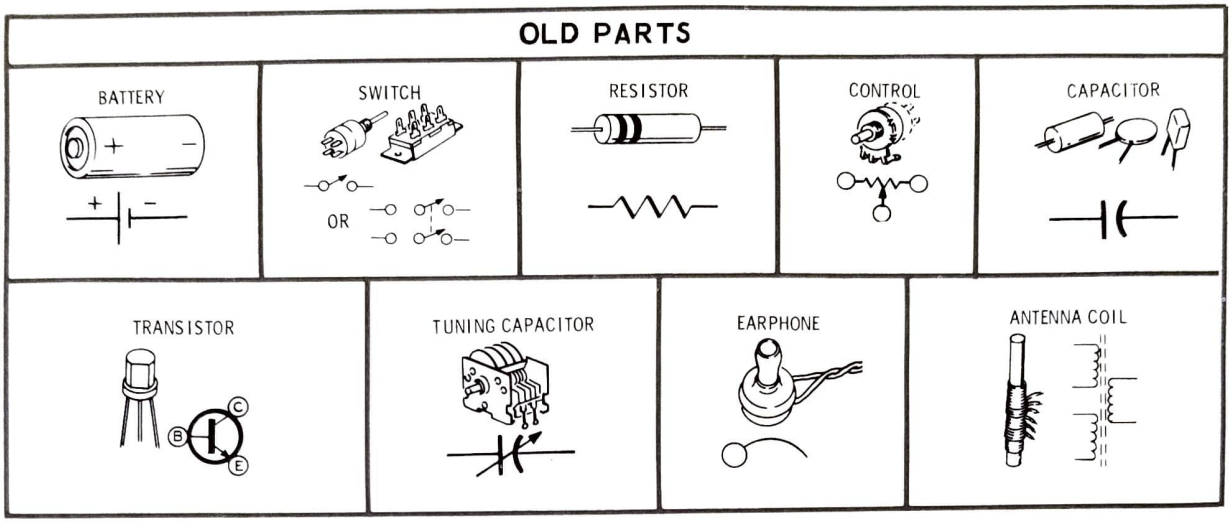
NOTE: It may be necessary to readjust the TUNING CAPACITOR and the CONTROL for the loud, clear sound.

( ) Turn off the CONTROL when you are not using the Transmitter.

APPLICATIONS

The voice transmitters you think of most commonly are used at radio and television stations. But voice transmitters are also used in many other applications, almost too numerous to mention. Some of these are: between police cars and police stations, between fire trucks and fire stations, between airplanes and ground, between railroad locomotives and railroad terminals, and in many different ways by all the armed forces.

PARTS



THINGS TO DO AFTER THE EXPERIMENT

( ) Disconnect the antenna wire from the ANTENNA terminal and reconnect it to A1.

Now, starting at the low end of the radio dial (550 kHz), try to find the highest frequency at which you can transmit your voice to the radio. Notice that, at higher frequencies, you can transmit at a greater distance from the radio.

WHAT HAPPENS IN THE CIRCUIT

Voice Transmitter

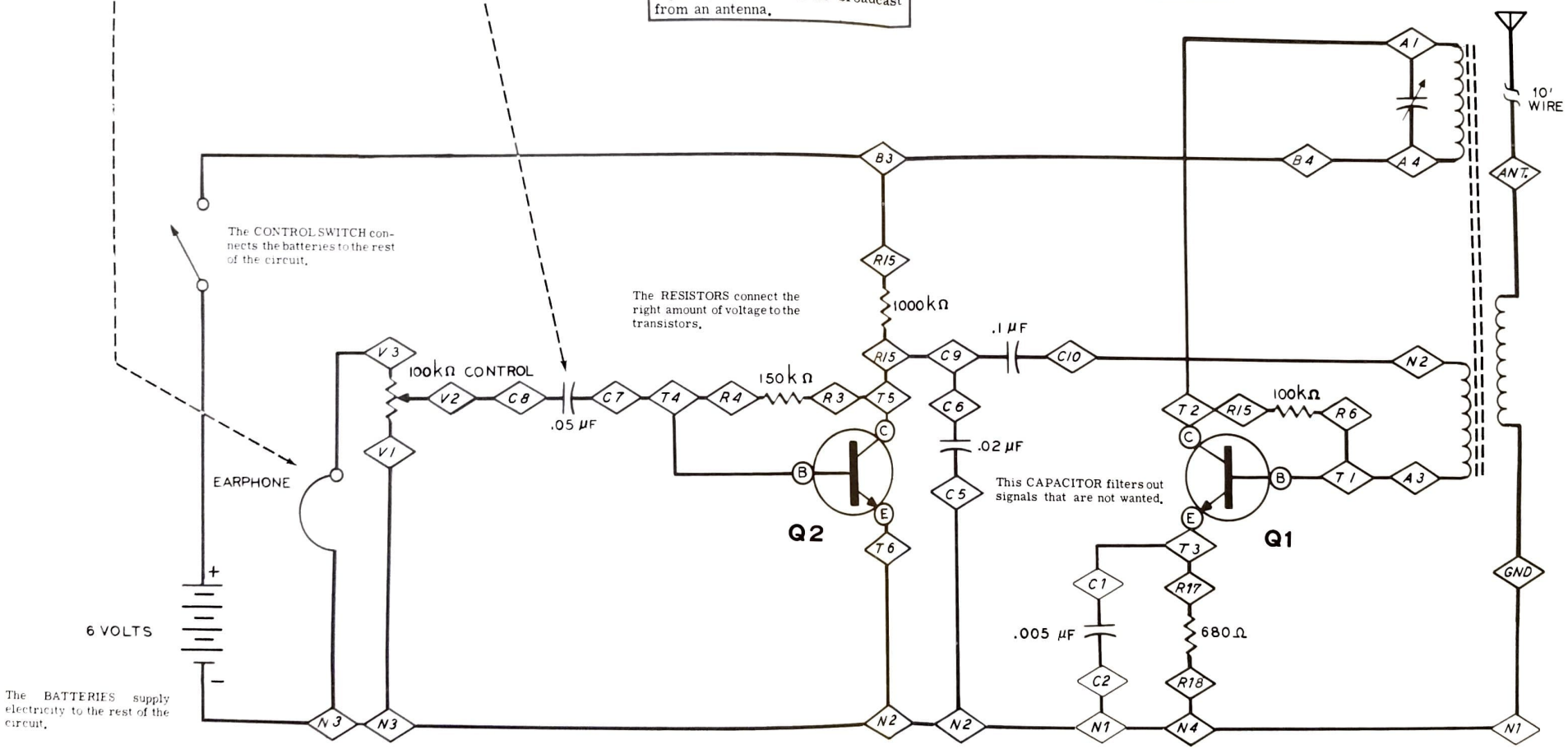
1 The EARPHONE changes sounds into electrical signals. These signals are then applied to the CONTROL.

2 From the CONTROL, the signal is coupled thru the .05 µF CAPACITOR to Q2, where it is amplified.

3 Transistor Q1, the ANTENNA COIL, and the TUNING CAPACITOR are connected as an oscillator circuit, a circuit that makes its own signal. This oscillator makes the kind of signal (RF) that can be broadcast from an antenna.

4 The voice signal from Q2 and the oscillator signal from Q1 are mixed together in Q1 and the ANTENNA COIL. This makes a radio signal with your voice signal attached to it.

5 The complete signal is broadcast from the ANTENNA.

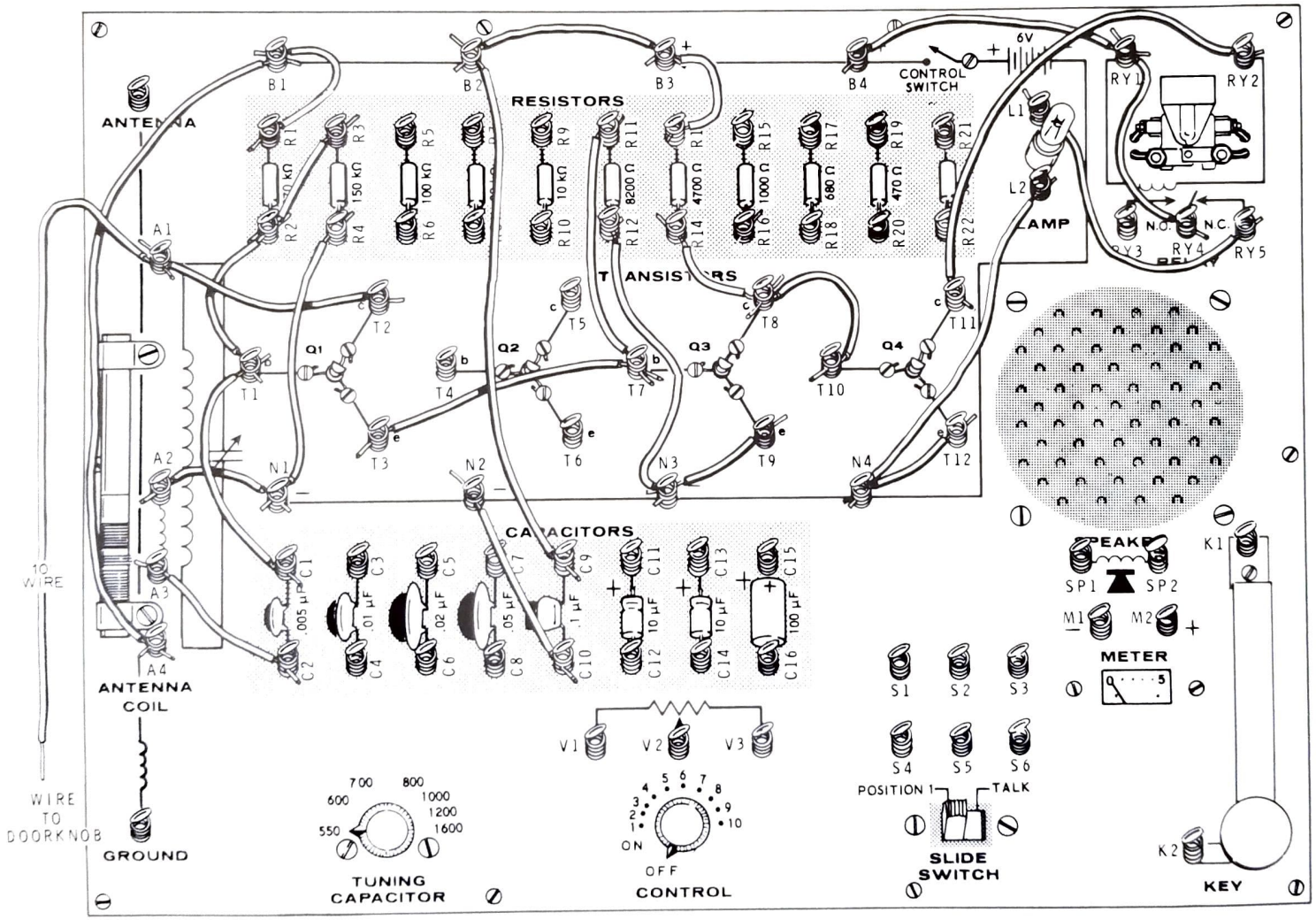


EXPERIMENT 33

Capacity Relay

A Capacity Relay is used to give a warning of some kind when someone gets near it or touches it. In this Experiment, you will connect a wire from the Capacity Relay to a doorknob, or some other metal object. Then the Lamp will light whenever anyone touches the doorknob.

Capacity Relays are used as detecting devices in burglar alarms, to tell when people come into a certain area, to count things on assembly lines, and in many other ways. The ones used in industry and as burglar alarms are much more sensitive than the one in this Experiment. These commercial capacity relays will operate as soon as anyone even gets near them.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
TWELVE 3" BLACK	B1	R1	
	B2	B3	R13
	R14	T8	T10
	T9	N3	
	N4	T12	
	N2	C10	
	N1	A2	
	T1	R2	R3
	C2	A3	
EIGHT 4" BROWN	A1	T2	
	T1	C1	
	T3	T7	
	RY1	RY4	
	RY5	L1	
	N3	R12	
	RY1	B4	
	T7	R11	
TWO 6" RED	R4	N1	
	N4	L2	
TWO 8" ORANGE	B2	C9	
	RY2	T11	
ONE 10" YELLOW	A4	B1	

OPERATION

TESTING

( ) Turn the TUNING CAPACITOR to 1600.

( ) Turn the CONTROL to ON. The Lamp should not be lit.

( ) Touch A1. The Lamp should light.

USING THE RELAY

NOTE: It is against government regulations to use a wire more than 10 feet long in the next step.

Do not connect the following wire to a very large metal object, like a metal desk or cabinet, or the circuit will not operate properly.

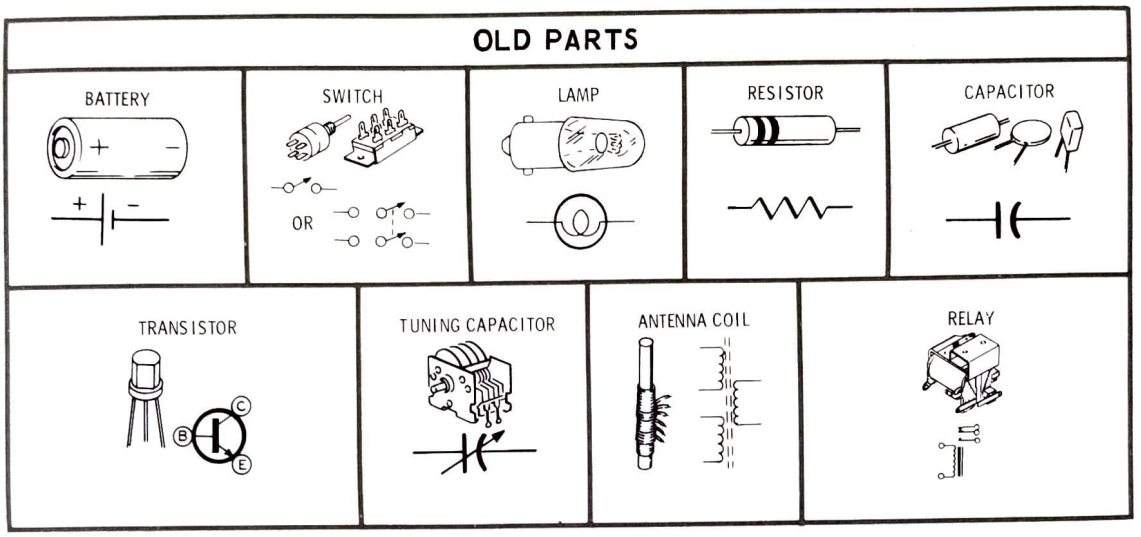
( ) Connect as short a wire as possible (less than 10 foot long) from A1 on the Workshop to a nonpainted part of a metal doorknob (or other metal object). This wire could be connected under the head of a screw, for example.

( ) Touch the doorknob. The Lamp should light. (If it does not light, have someone hold the doorknob while you turn the TUNING CAPACITOR slowly counterclockwise until the Lamp does light.)

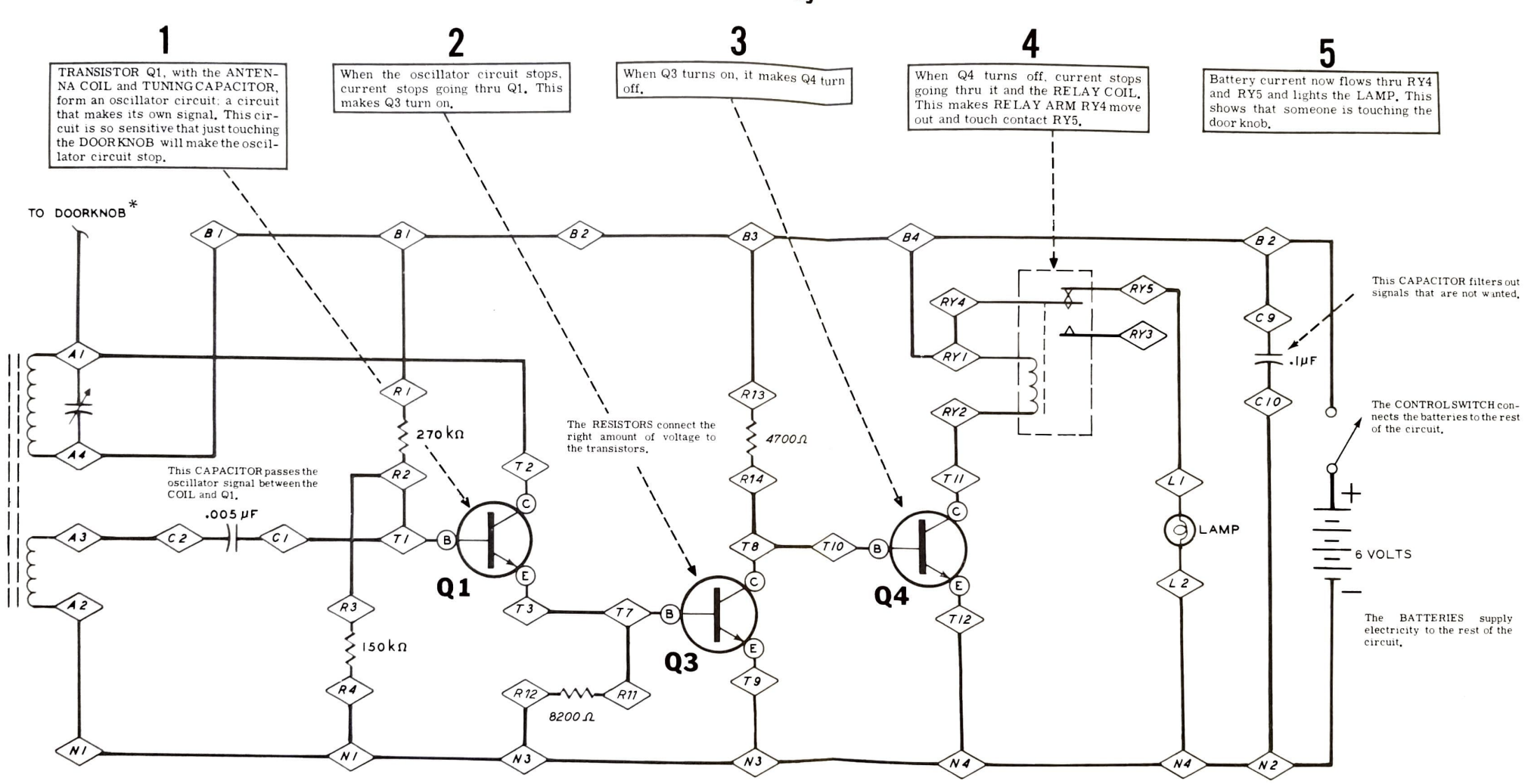
The Capacity Relay is now in operation. It will light the Lamp anytime someone touches the doorknob.

( ) Turn off the CONTROL when you complete the Experiment.

PARTS


OLD PARTS
BATTERY
+
−
+
−
SWITCH
OR
LAMP
RESISTOR
CAPACITOR
TRANSISTOR
B
C
E
TUNING CAPACITOR
ANTENNA COIL
RELAY

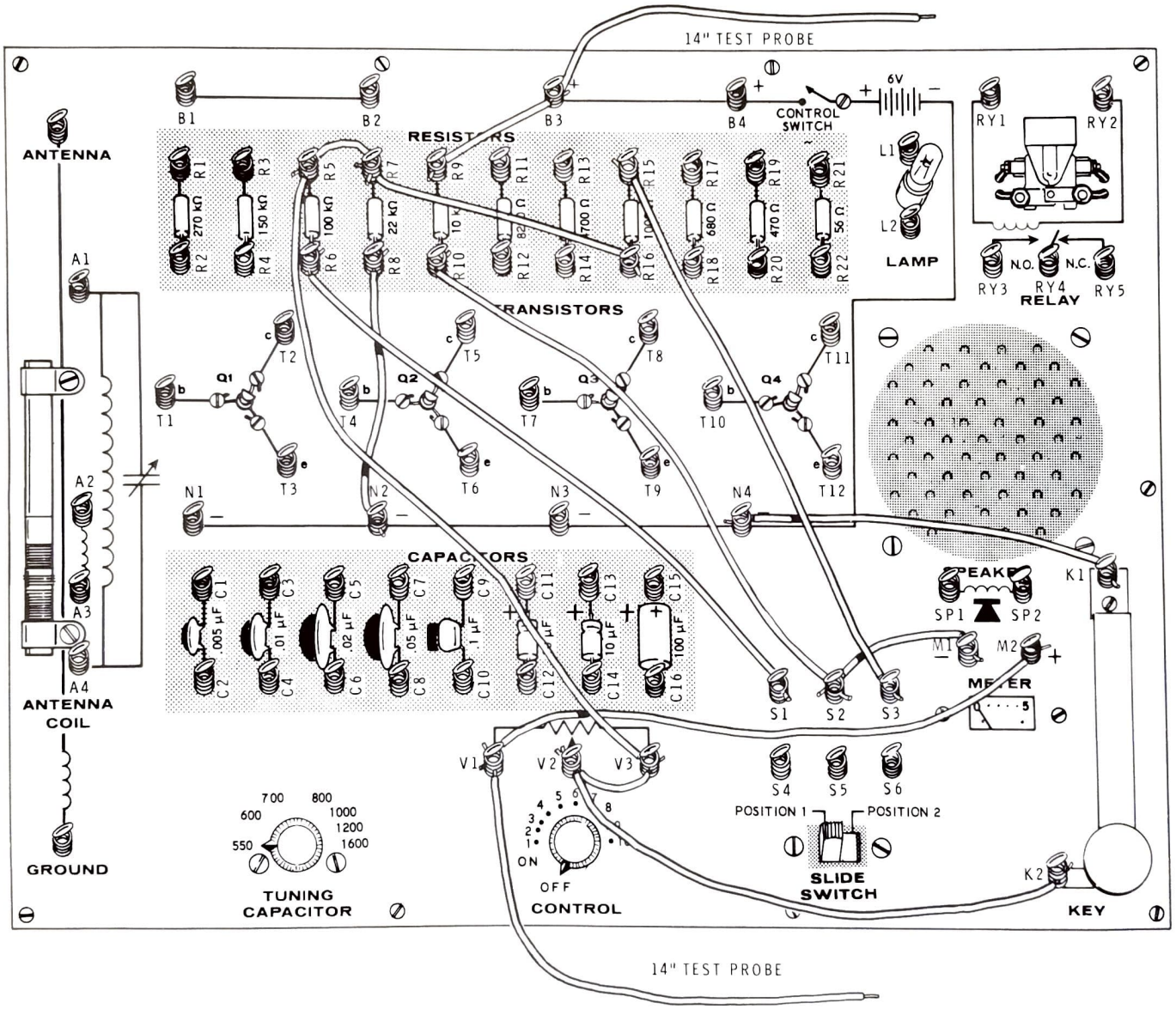
WHAT HAPPENS IN THE CIRCUIT



* THIS WIRE MUST NOT BE ANY LONGER THAN 10".

EXPERIMENT 34
Wheatstone Bridge

A Wheatstone Bridge is a laboratory instrument used to accurately measure resistance. This Experiment will help you learn how it operates.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
FOUR 3" BLACK	R5	R7	
	R9	B3	
	V2	V3	
	S2	M1	
ONE 4" BROWN	R8	N2	
TWO 6" RED	N4	K1	
	R7	R16	
TWO 8" ORANGE	V2	K2	
	V1	M2	
FOUR 10" YELLOW	S2	R10	
	S1	R6	
	R15	S3	
	R5	V3	
TWO 14" BROWN	V1		
TEST PROBES	B3		

CALIBRATION

( ) 1. Connect one test probe end to R11.

( ) 2. Connect the other test probe end to R12.

( ) 3. Place the SLIDE SWITCH in Position 1.

( ) 4. Turn the CONTROL clockwise to ON. The Meter pointer should move to the left of zero.

( ) 5. Turn the CONTROL clockwise slowly until the Meter pointer moves to zero.

( ) 6. Push the KEY. Then slowly adjust the CONTROL again until the Meter reads zero. The bridge is properly balanced when the Meter pointer does not move while you press and release the KEY.

The CONTROL knob should now be pointing at just a little over 8 (8.2), indicating that the electrical size of this resistor is 8200 Ω (ohms). If it does not, loosen the control knob setscrew, and carefully reposition the pointer at 8.2. Then, tighten the setscrew again.

These steps have shown you how a Wheatstone Bridge works by measuring the 8200 Ω (ohm) resistor. Other resistors can also be measured in this same manner, but because this circuit does not use expensive parts, the measurements may not be very accurate. Professional Wheatstone Bridges use very elaborate, precision parts to make sure they measure accurately. They also have more controls.

OPERATION

NOTE: When the SLIDE SWITCH is in Position 1, you can connect the test probes to measure any resistance value between 1000 Ω and 10 kΩ. When the SLIDE SWITCH is in Position 2, you can connect the test probes to measure any resistance between 100 kΩ and 1000 kΩ (1 million ohms, or 1 MΩ). The following Examples will demonstrate how the Wheatstone Bridge operates.

EXAMPLE #1: MEASURING THE 4700 Ω RESISTOR.

( ) Disconnect the test probe from R11 and connect it to R13.

( ) Disconnect the test probe from R12 and connect it to R14.

( ) Now measure the resistor by repeating steps 4, 5, and 6 on Page 145. The CONTROL knob should point to approximately 4.7, indicating that the electrical size of this resistor is 4700 Ω.

EXAMPLE #2: MEASURING THE 150 kΩ RESISTOR.

( ) Disconnect the test probe from R13 and connect it to R3.

( ) Disconnect the test probe from R14 and connect it to R4.

( ) Place the SLIDE SWITCH in Position 2.

( ) Now measure the resistor by repeating steps 4, 5, and 6. The CONTROL knob should point to approximately 1.5, indicating that the electrical size of this resistor is 150 kΩ.

EXAMPLE #3: MEASURING THE 270 kΩ RESISTOR.

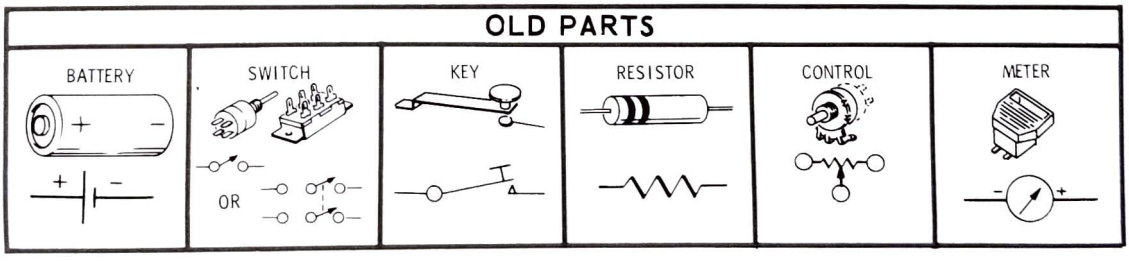
( ) Disconnect the test probe from R3 and connect it to R1.

( ) Disconnect the test probe from R4 and connect it to R2.

( ) Now measure the resistor by repeating steps 4, 5, and 6. The CONTROL knob should point to approximately 2.7, indicating that the electrical size of this resistor is 270 kΩ.

( ) Turn off the CONTROL.

PARTS



WHAT HAPPENS IN THE CIRCUIT

Wheatstone Bridge

1

A BRIDGE is like an electrical scales. This one is used to measure resistance.

2

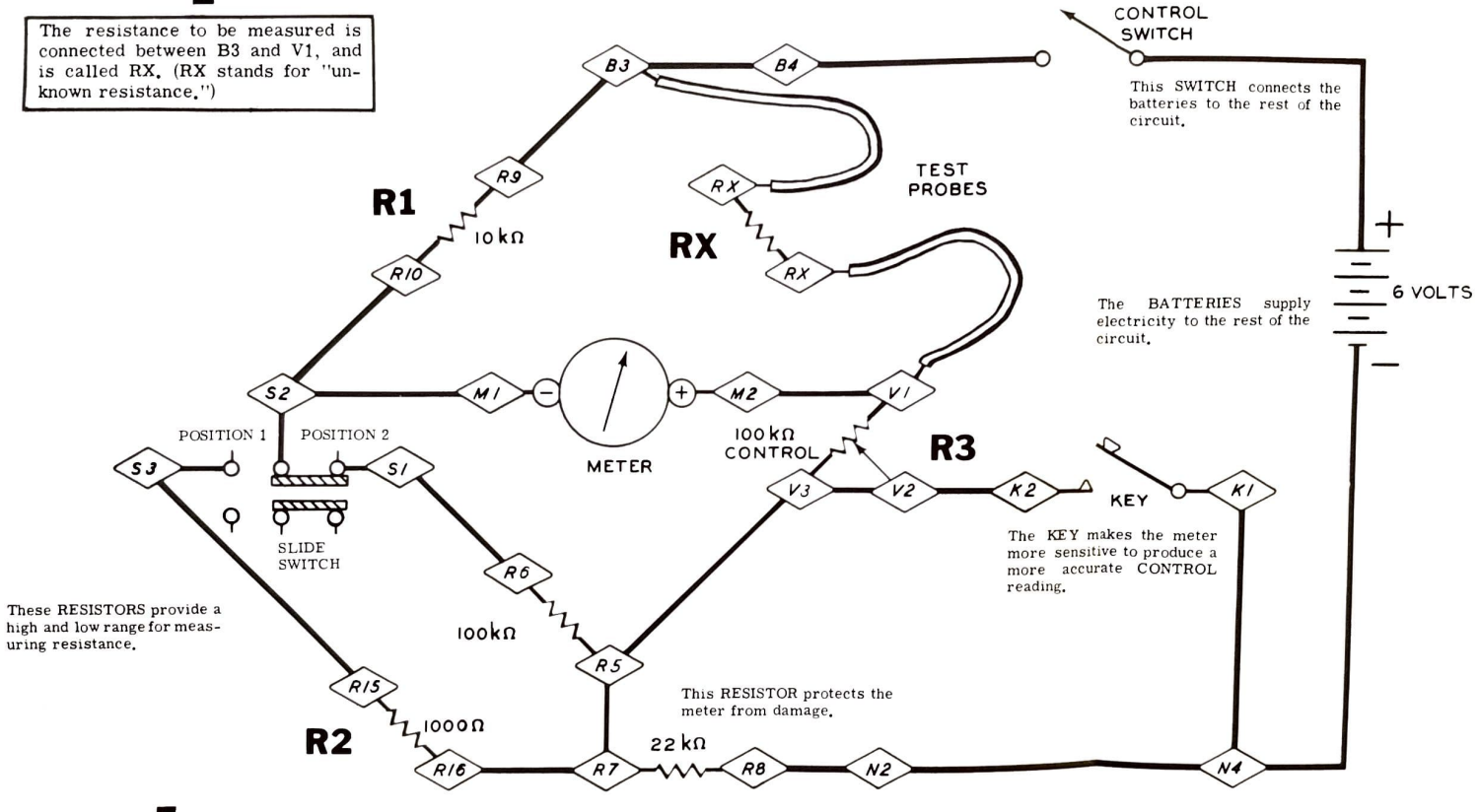
The resistance to be measured is connected between B3 and V1, and is called RX. (RX stands for "unknown resistance.")

3

Current will flow thru both the left-hand side (R1 and R2) and the right-hand side (RX and R3) of the Bridge. When the CONTROL is adjusted so no current goes thru the Meter in the center, the Bridge (electrical scales) is balanced.

4

When the Bridge is balanced, the setting of the CONTROL (and the setting of the SLIDE SWITCH) can be used to tell you how large the resistance is.



5

The SLIDE SWITCH gives you two measuring ranges. Position 1 is the Low Range: multiply the Control setting x 1000. Position 2 is the High Range: multiply the Control setting x 100,000.

6

EXAMPLES

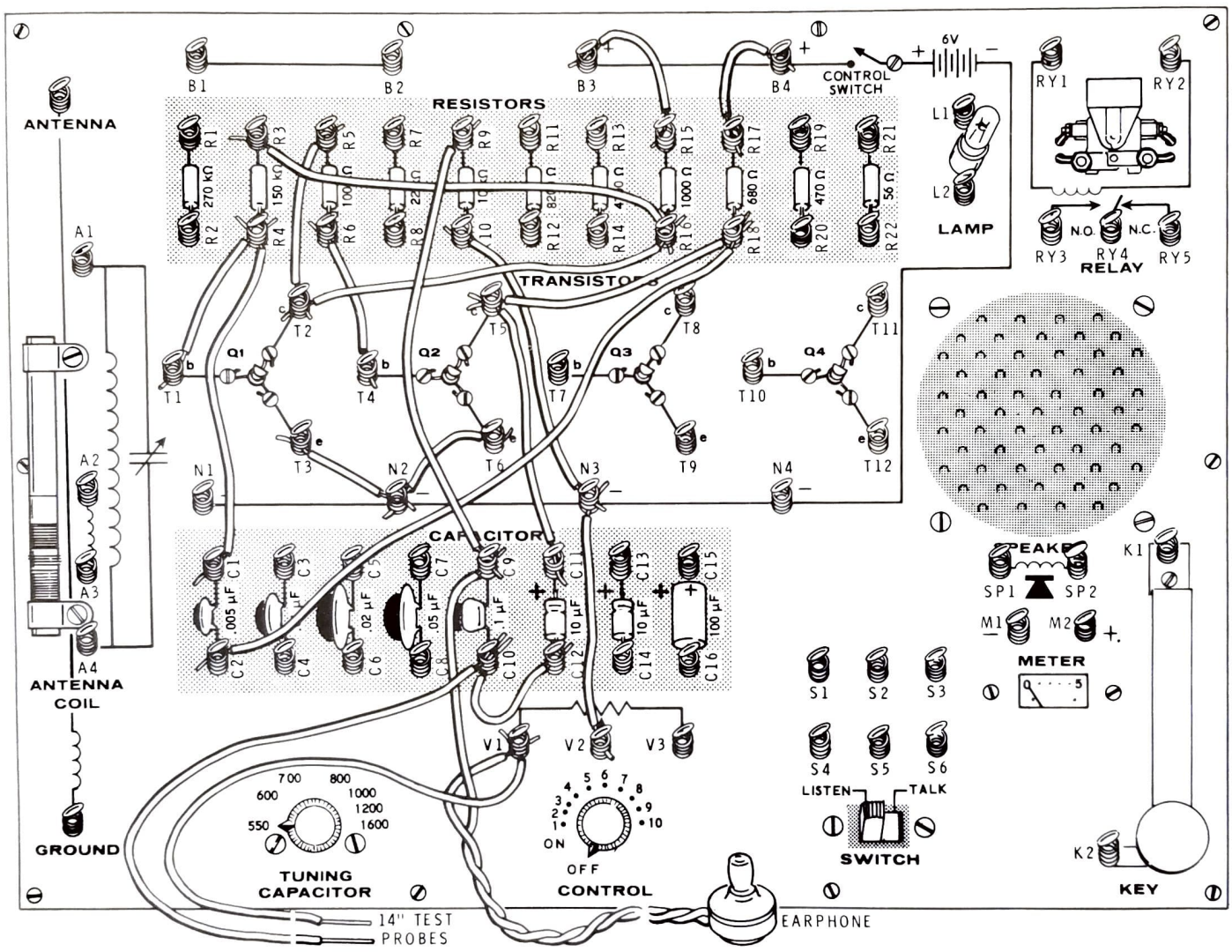
1. Control setting: 1-1/2
   Slide Switch: Position 1
   $RX = 1\text{-}1/2 \times 1000 = 1500\ \Omega$

2. Control setting: 3
   Slide Switch: Position 2
   $RX = 3 \times 100{,}000 = 300{,}000\ \Omega$

EXPERIMENT 35
Capacitor Bridge

Capacitor Bridges are used to measure the electrical size of CAPACITORS. They are used in laboratories for research and testing, and by radio and television repairmen to locate bad capacitors. This Experiment will help you learn how they operate.

NOTE: Be sure you have done Experiment 34 before you do this Experiment. This will calibrate the CONTROL so you will get more accurate measurements with this Capacitor Bridge.



WIRING CHART			
USE	FROM	TO	
		FROM	TO
EIGHT 3" BLACK	T2	R5	
	R4	T1	
	T3	N2	T6
	B3	R15	
	B4	R17	
	R6	T4	
	C10	C12	
THREE 4" BROWN	C11	T5	R18
	V2	N3	
FIVE 6" RED	R3	R16	T2
	R9	C9	
	R10	N3	
	C1	R4	
ONE 10" YELLOW	C2	R18	
EARPHONE	C9	V1	
TWO 14" BROWN	V1		
TEST PROBES	C10		

OPERATION

TESTING

( ) Connect one test probe to C5.

( ) Connect the other test probe to C6.

( ) Place the Earphone in your ear.

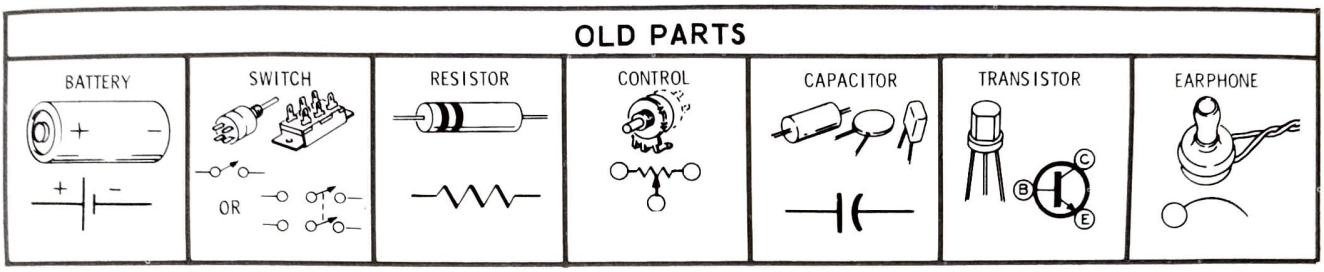
( ) Turn the CONTROL past position 10.

( ) Then turn the CONTROL counterclockwise slowly until you hear no sound. The knob should be pointing to about 5.

( ) Now use the number the CONTROL knob points to with the formulas in boxes 7 and 8 on the Schematic (Page 151). The formulas will give you an indication of the electrical size of the capacitor (.02 μF).

( ) Turn off the CONTROL when you complete the Experiment.

PARTS



THINGS TO DO AFTER THE EXPERIMENT

Repeat the previous steps except connect the test probes to C7 and C8.

NOTE: The formula should give an answer of about .05 μF.

WHAT HAPPENS IN THE CIRCUIT

Capacitor Bridge

1

Q1 and Q2 form an OSCILLATOR circuit, a circuit that makes its own signal. The .01 μF CAPACITOR helps make the signal.

2

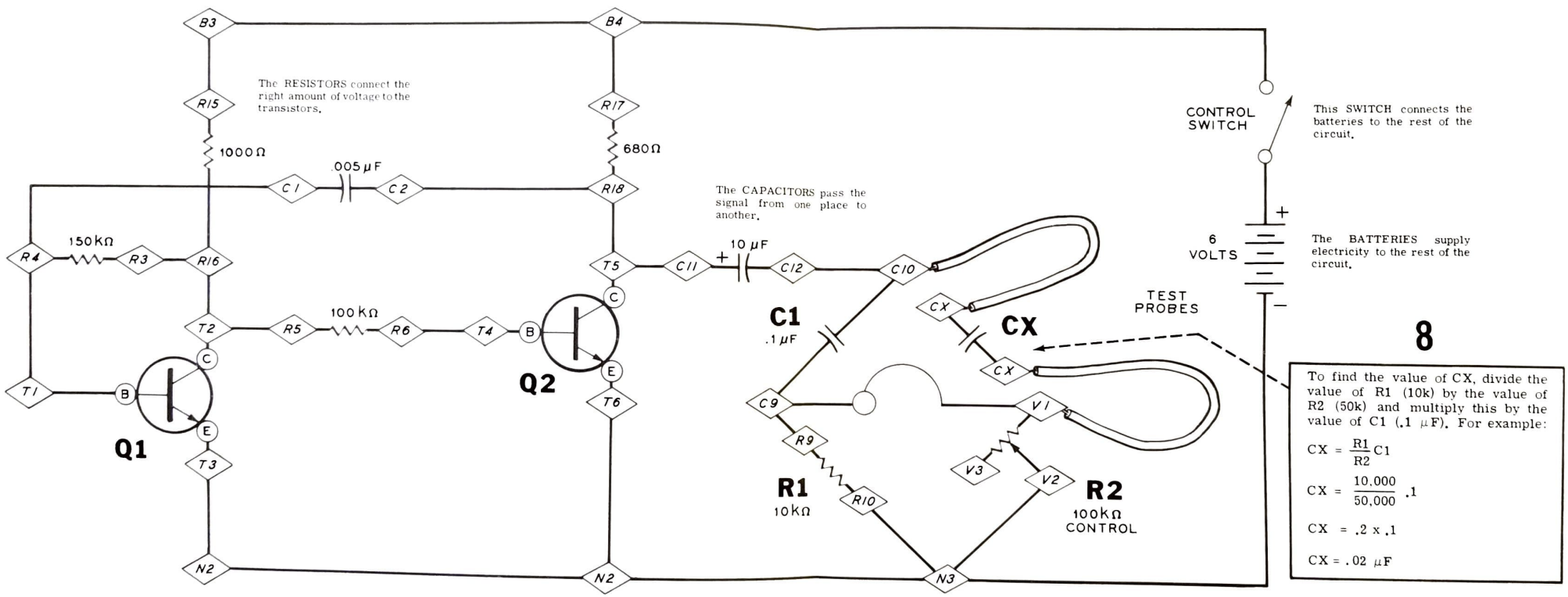
The signal developed by Q1 and Q2 is passed thru the 10 μF CAPACITOR to the Bridge circuit.

3

A BRIDGE is like an electrical scale. This one is used to measure the electrical size (capacitance in μF) of unknown capacitors.

4

The capacitor to be measured is connected between C10 and V1, and is called CX. (CX stands for "unknown capacitor.")



5

Current will flow thru both the left-hand side (C1 and R1) and the right-hand side of the Bridge. When the CONTROL (R2) is adjusted for least sound (least signal) thru the Earphone in the center, the bridge (electrical scale) is balanced.

6

When the Bridge is balanced, you can find the value of capacitor CX by following the directions in boxes 7 and 8.

7

First, find the value of R2 by multiplying the CONTROL setting by 10,000. For example, if the CONTROL setting is 5, then 5 x 10,000 = 50,000 Ω or 50 k.

8

To find the value of CX, divide the value of R1 (10k) by the value of R2 (50k) and multiply this by the value of C1 (.1 μF). For example:

$$CX = \frac{R1}{R2} C1$$

$$CX = \frac{10,000}{50,000} .1$$

$$CX = .2 \times .1$$

$$CX = .02\ \mu F$$

IN CASE OF DIFFICULTY

Any difficulty you have will be due to one of the following three causes:

1. Because an Experiment was not wired correctly.

2. Because the Workshop was not assembled correctly.

3. Because of a faulty part.

If you still cannot find your trouble after following these directions, refer to Pages 14 and 15 of the Kit Builders Guide. These pages will tell you how you can get help from the Heath Company.

CAUSE #1: EXPERIMENT WIRING CHECKS

Because faulty wiring is the most likely cause of a difficulty, you should make the following checks first if an Experiment does not work properly.

1. Be sure each wire is fastened to the right place. Check for a wrong connection where you see more than two wires at a spring, or a part with only one wire connected to it. Check each wire against the Wiring Chart and Pictorial.

2. Make sure each wire end is fastened tightly to a spring.

3. For radio receiver Experiments, check the antenna and ground connections at both ends of these wires. (NOTE: A wire will not make a good connection if it is connected to a painted surface.)

4. You might cure your trouble by removing all wires and rewiring the Experiment.

5. Your science teacher, or a local amateur radio operator or TV serviceman, may be able to look at the Experiment and tell you what is wrong.

CAUSE #2: WORKSHOP ASSEMBLY CHECKS

1. Be sure the shoulder washer is properly mounted at the end of each battery bracket. Refer to the Note at the top of Page 20.

2. Check the batteries to be sure they all face in the right direction. Also be sure they are good by trying them in a flashlight. The flashlight should glow brightly.

3. Be sure all hardware is tightened all the way, and that each wire is properly connected under its nut, screw, or spring.

4. Be sure all wires go to the right places. Check them against Pictorial 1B (fold-out from Page 23).

5. Be sure each wire touches only its own connection. A wire could easily touch more than one terminal, for example, on a switch, meter, or tuning capacitor. This is called a "short circuit."

6. Be sure each capacitor and resistor is installed in the right place. The electrical size marking on each capacitor (.01, for example, or .1) should match the marking on the Workshop. See Pages 10 and 11.

7. Be sure each transistor is properly installed. The flat side should face toward the resistors and be turned part way toward the Relay. Check carefully to be sure each lead goes to the right place. The center lead should go to C. Refer to the steps under "Transistors" on Page 9.

CAUSE #3: CHECKING FOR BAD PARTS

The following paragraphs tell you how to use the tests in this section. Complete the Lamp and Control Switch Test first. Then locate the tests for the parts you want to test. After you complete each test, turn the Control to OFF and disconnect all wires from the Workshop.

If a part seems to be faulty, you can get a replacement part in one of several ways:

1. Write for a new part to the Heath Company, Benton Harbor, Michigan 49022. See "Replacement Parts" on Page 14 of the "Kit Builders Guide".

2. Contact your nearest Heathkit Electronic Center or Authorized Service Center. These are listed in your Heath Catalog.

3. Obtain a new part of the same type from a local electronic parts store or TV service shop.

NOTE: Be sure to give the part number of the bad part if you contact the Heath Company or a Heathkit Center. Refer to the Replacement Parts Price List on Page 165.

LAMP AND CONTROL SWITCH TEST

( ) Connect a 3" black wire from B4 to L1.

( ) Connect a 6" red wire from L2 to N4.

( ) Turn the Control to ON. The Lamp should light. If it lights properly, the Lamp and the Control Switch are operating properly. Go on to the next Test.

If the Lamp does not light properly, make the following test.

( ) Touch a screwdriver blade, at the same time, to terminals 4 and 5 of the Control Switch. See Pictorial 1 (fold-out from Page 7).

1. If the Lamp does not light, the Lamp is faulty and should be replaced.

2. If the Lamp lights, the Control Switch is faulty. Remove the wires and springs from control switch terminals 4 and 5. Then reconnect them to the other two terminals near 4 and 5. If the Lamp still does not light, replace the Control.

SPEAKER, EARPHONE, ANTENNA COIL, REMOTE STATION, AND SLIDE SWITCH TESTS

( ) Connect a 3" black wire from B4 to L1.

( ) Connect one end of a 14" brown test probe to L2.

( ) Connect one end of another 14" brown test probe to N4.

( ) Turn the Control to ON.

Speaker

( ) Touch one test probe to SP1, the other probe to SP2. The Speaker should thump and the Lamp should light dimly.

Earphone

( ) Touch one test probe to each earphone lead. The Earphone should thump very lightly, but the Lamp should not light.

Antenna Coil

Touch the test probes to the following Antenna connections. The Lamp should light as you touch each pair.

	TOUCH ONE PROBE TO:	TOUCH THE OTHER PROBE TO:
( )	ANTENNA	GROUND
( )	A1	A4
( )	A2	A3

NOTE: The Lamp should not light when you touch the probes to any other pair of Antenna connections.

Remote Station

( ) Touch one test probe to SP3, the other probe to COM. The Speaker should thump and the Lamp should light dimly.

NOTE: If the Lamp lights brightly and the Speaker does not thump, check to see that the shoulder washer is properly placed at SP3.

( ) Connect one test probe to SP3 and the other test probe to K3. Neither the Speaker or the Lamp should operate. If they do, check to see that both shoulder washers at K3 are properly placed. Also be sure the speaker wires are properly installed.

( ) Press the Key. Both the Speaker and Lamp should operate. If neither operates, make sure the screws at the rear of the Key and at the COM terminal are tight.

Slide Switch

( ) Place the Slide Switch in Position 1.

Touch the test probes to the following Switch terminals. The Lamp should light as you touch each pair.

	TOUCH ONE PROBE TO:	TOUCH THE OTHER PROBE TO:
( )	S1	S2
( )	S4	S5

The Lamp should not light when you touch any other pair of Slide Switch connections (in Position 1).

( ) Place the Slide Switch in Position 2.

Touch the test probes to the following Switch terminals. The Lamp should light as you touch each pair.

	TOUCH ONE PROBE TO:	TOUCH THE OTHER PROBE TO:
( )	S2	S3
( )	S5	S6

The Lamp should not light when you touch any other pair of Slide Switch connections (in Position 2).

RELAY

( ) Connect a 4" brown wire from L2 to RY3.

( ) Conect a 6" red wire from B3 to L1.

( ) Connect an 8" orange wire from RY4 to N3.

( ) Connect a 10" yellow wire from RY2 to N4.

( ) Connect one end of a 6" red wire to RY1.

( ) Turn the Control to ON.

( ) Touch the 6" red wire coming from RY1 to B4. The Relay should click and the Lamp should light. If the Relay does not click, check the wiring at RY1 and RY2.

( ) Turn off the Control.

( ) Disconnect the wire RY3 and reconnect it to RY5.

( ) Turn on the Control. The Lamp should light.

( ) Touch the 6" red wire coming from RY1 to B4. The Lamp should turn off.

If the Relay clicks but the Lamp does not light properly, check the wiring at RY3, RY4, and RY5.

RESISTORS

( ) Connect one end of a 14" brown test probe to B4.

( ) Connect one earphone lead to N4. If it is more convenient later, change this lead to N3, N2 or N1.

( ) Turn on the Control.

( ) Connect the loose end of the test probe to R21.

( ) Touch the loose earphone lead to R22; the Earphone should thump.

Check each of the other resistors in the same manner. Connect the test probe to the odd numbered resistor springs and the earphone to the even numbered springs. The resistor between R21 and R22 will sound the loudest, while the resistor between R1 and R2 will sound the softest.

METER

( ) Connect a 4" brown wire from N4 to M1.

( ) Connect a 6" red wire from B3 to R5.

( ) Connect a 12" black wire from M2 to R6.

( ) Turn on the Control. The meter needle should be at about 2-1/2. If the needle does not move, check the meter wiring.

If the meter needle moves to the left of zero, the Meter was wired backwards or the batteries were installed backwards.

CONTROL

( ) Connect a 4" brown wire from B3 to R7.

( ) Connect a 4" brown wire from V1 to N3.

( ) Connect a 4" brown wire from M1 to N4.

( ) Connect an 8" orange wire from R8 to V3.

( ) Connect an 8" orange wire from V2 to M2.

( ) Turn the Control to ON. The Meter should read zero.

( ) Turn the Control clockwise. The needle should reach 5 when the Control is fully clockwise.

10 μF AND 100 μF ELECTROLYTIC CAPACITORS

( ) Connect a 4" brown wire from R7 to B3.

( ) Connect a 4" brown wire from N4 to M1.

( ) Connect one end of a 14" brown test probe to R8.

( ) Connect one end of a 14" brown test probe to M2.

( ) Turn the Control to ON.

Before you test each capacitor, touch a 3" wire to both of its connectors at the same time. Then remove the wire.

When you first touch the test probes to a capacitor, the meter needle should move quickly up-scale. Then the needle should move (usually more slowly) back down to zero again. If the needle does not move up-scale or does not return to zero, the capacitor is not good or was installed backwards (or you did not touch both ends of it with the 3" wire before you tested it). The meter needle will move more slowly for the 100 μF capacitor.

CAPACITOR	CONNECT THE TEST PROBE FROM M2 TO:	CONNECT THE TEST PROBE FROM R8 TO:
( ) 100 μF	C16	C15
( ) 10 μF	C14	C13
( ) 10 μF	C12	C11

OTHER (.005 μF TO .1 μF) CAPACITORS

Wiring The Tester

( ) Connect a 3" black wire from T9 to T10.

( ) Connect a 4" brown wire from B3 to R7.

( ) Connect a 4" brown wire from M1 to N4.

( ) Connect a 4" brown wire from T8 to T11.

( ) Connect a 6" red wire from T12 to M2.

( ) Connect an 8" orange wire from R8 to T11.

( ) Connect one end of a 14" brown test probe to T8.

( ) Connect one end of another 14" brown test probe to T7.

( ) Turn the Control to ON.

( ) Touch the two test leads together. The meter needle should indicate at 5. If the needle does not, test transistors Q3 and Q4 before you complete these capacitor tests.

Testing Capacitors

Before you test each capacitor, touch a 3" wire to both of its connectors at the same time. Then remove the wire.

When you first touch the test probes to a capacitor, the meter needle should move quickly up-scale and then back down to zero again. If the needle does not move up-scale or does not return to zero, the capacitor is faulty (or you did not touch both ends of it with a 3" wire before you tested it). The needle may not move very far for the electrically small capacitors, especially for the .005 μF capacitor.

CAPACITOR	CONNECT THE TEST PROBE FROM T8 TO:	CONNECT THE TEST PROBE FROM T7 TO:
( ) .1 μF	C9	C10
( ) .05 μF	C7	C8
( ) .02 μF	C5	C6
( ) .01 μF	C3	C4
( ) .005 μF	C1	C2

TRANSISTORS

NOTE: You may also check the transistors by checking them with the Transistor Tester of Experiment 5.

( ) Connect a 4" brown wire from R7 to B3.

( ) Connect a 4" brown wire from N4 to M1.

( ) Connect one end of a 14" brown test probe to R8.

( ) Connect one end of another 14" brown test probe to M2.

NOTE: A transistor will not check OK if it is not installed correctly. Be sure each lead goes to the right conector.

This circuit tests a transistor when you touch your fingers to its C and B connectors. This will not give you a shock.

( ) Connect the test probe coming from R8 to the C connector of the transistor to be tested (T11, T8, etc.).

( ) Connect the test probe coming from M2 to the E connector of the transistor to be tested (T12, T9, etc.).

( ) Turn on the Control; the Meter should indicate zero. If the Meter indicates above zero, the transistor is bad or was wired wrong.

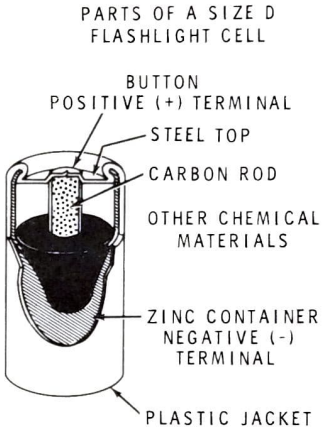
( ) Wet two fingers slightly and touch the B and C springs of that transistor. The Meter needle should move up-scale. If the Meter does not read, the transistor is faulty or was wired wrong.

DICTIONARY

NOTE: The Page numbers, listed after the part names below, refer to where this part was first described.

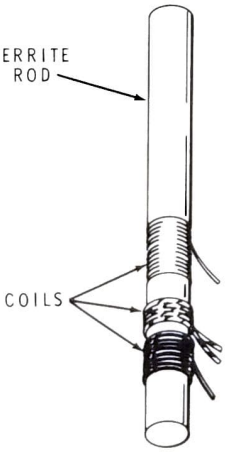
POSITIVE (+) NEGATIVE (−) - Electrons only go one way in some parts, such as batteries and meters. The end of a battery that the electrons flow out of is called the "negative" (-) end. The end of a battery that the electrons flow into is called the "positive" (+) end. The positive end of a meter or electrolytic capacitor has to be connected toward the positive end of the battery.

BATTERY (Page 31) - A battery uses chemicals to make electricity. A carbon rod forms the positive (+) pole of the battery. A zinc container forms the negative (-) pole. Other chemical materials separate the carbon rod from the zinc container.

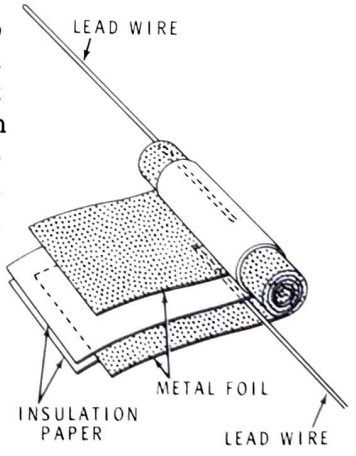


Electrons are pushed out from the negative (-) end of the battery, go thru the circuit, and then go back into the positive (+) end. When the chemicals are all used up, no more electrons are given off.

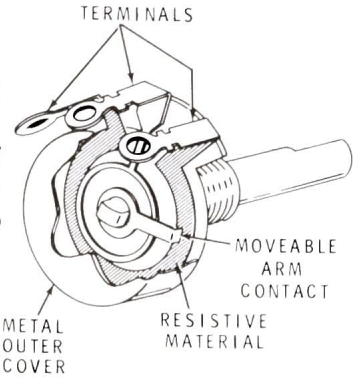
ANTENNA COIL (Page 116) - The antenna coil is made of three coils of wire wound around a ferrite (an iron compound) rod. The first coil is at the bottom and is connected to the Antenna and Ground springs. The second is the white coil that goes from A1 to A4. The third coil is the white-red one connected to A2 and A3. A group of coils spaced close together like this can take a radio signal that comes in on one coil and transfer it to the other coils.



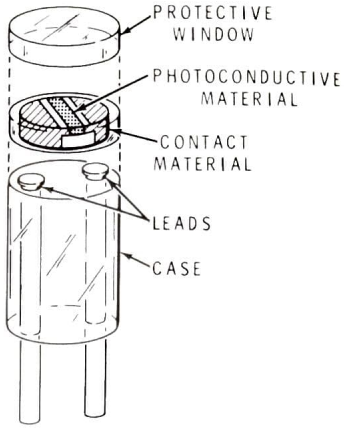
CAPACITOR (Page 54) - A very simple capacitor could be made of two metal plates spaced close to each other (but not touching). Actually, most capacitors are made as shown in the illustration. A "sandwich" is made of two sheets of metal foil that are separated by a sheet of insulating paper. Then the sheets are rolled up so the capacitor will not take up much space but still will have a large plate area.



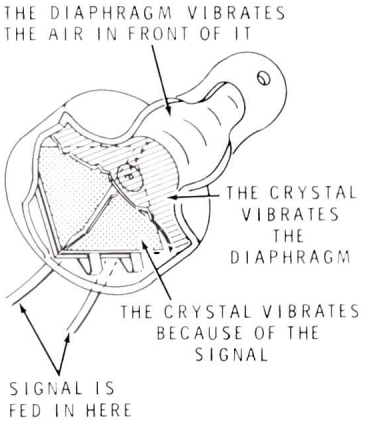
CONTROL (Page 36) - A control is actually just a different kind of resistor. The arm of the control can be moved to any place on a strip of resistive material. This changes the amount of resistance between the arm and the other two terminals.



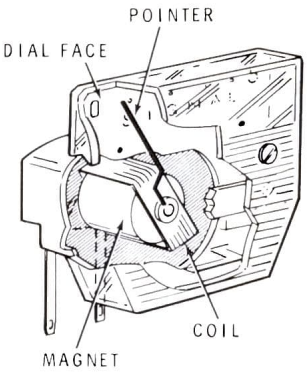
LDR (Page 96) - An LDR, or light dependent resistor, is made by putting a piece of photoconductive material in a transparent case. The resistance of this piece, which is connected between two leads, decreases as more light strikes it and increases as it gets darker. Electrons, then, flow thru it easier when it is lighted. In the dark, its resistance is high; this makes it hard for electrons to flow thru it.



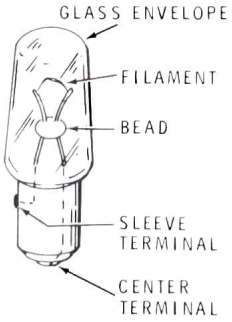
EARPHONE (Page 60) - An earphone changes signals into sounds; but since it is much smaller than a speaker, the sounds cannot be heard very far away from it. The illustration shows what the inside of your earphone looks like.



METER (Page 36) - The meter consists of a magnet, a meter pointer that is fastened to a coil, and a meter face with markings on it. When current goes thru the coil it makes magnetism. The magnetism from this coil pushes against the magnetism from the magnet, and this pushing makes the coil turn. The pointer then moves from zero to another place on the meter face. As more current flows, the coil turns farther and the meter pointer moves farther up-scale.

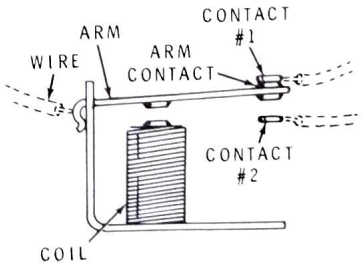


LAMP (Page 32) - Electrons flow in one terminal of a lamp, go thru the fine wires of the filament, and out the other terminal. The electrons cause the filament to get white hot and give off light.

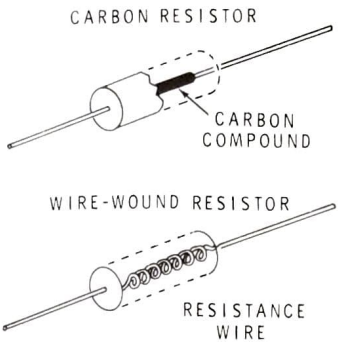


The glass envelope is put around the bulb so air can be removed from around the filament. The filament would burn up immediately if the air were left around it. With no air, the filament will not burn out for a long time.

RELAY (Page 55) - A relay is normally used as an automatic switch. When current goes thru the coil, the contacts can be used as a switch to turn on or turn off some other device or circuit.

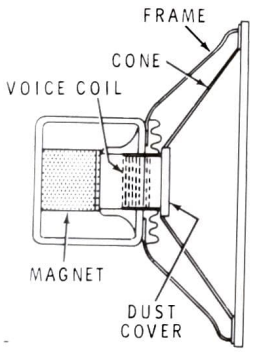


RESISTOR (Page 36) - A resistor resists the flow of electric current. The unit of resistance is an ohm (Ω). A resistor that offers a lot of resistance to currents will have a large number of ohms, and a resistance that only offers a small amount of resistance to currents will have a small number of ohms.



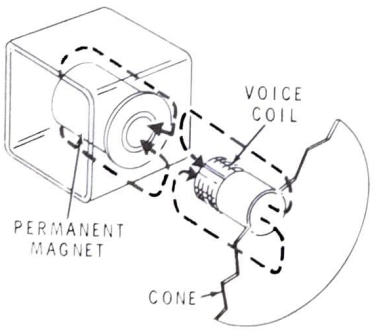
Resistors are usually made from either a carbon compound or a length of resistance wire made from metal alloys. The accompanying illustrations show how typical carbon and wire-wound resistors are constructed.

SPEAKER (Page 60) - A speaker changes electronic signals into sounds. The accompanying illustrations show how your speakers are constructed and how they operate.



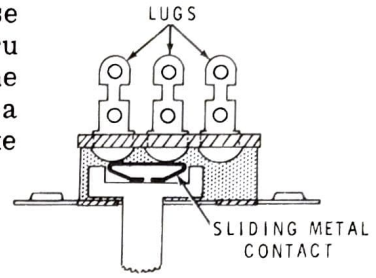
A. THE AMOUNT OF CURRENT IN THE VOICE COIL DETERMINES THE AMOUNT OF MAGNETISM IN THE VOICE COIL.

B. THE AMOUNT OF MAGNETISM IN THE COIL DETERMINES HOW FAR THE COIL IS PUSHED AWAY FROM THE PERMANENT MAGNET.



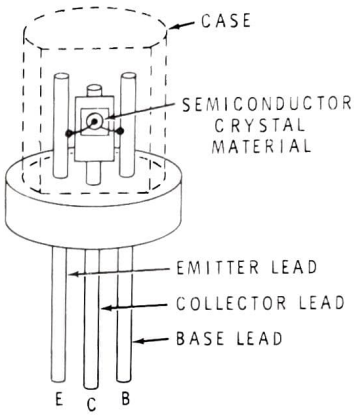
THE CONE MOVES THE AIR IN FRONT OF (AND IN BACK OF) THE SPEAKER.

SWITCH (Page 32) - Switches open and close to let current pass thru them. The drawing at the right shows you what a typical switch looks like on the inside.



TRANSISTOR (Page 50) - Transistors are made from a special type of crystal. This type of crystal is called a semiconductor.

A transistor contains three semiconductor crystals put together in the form of a sandwich. One type of crystal is in the center, and another type is on each side of it.



The accompanying illustration shows how a typical transistor is constructed.

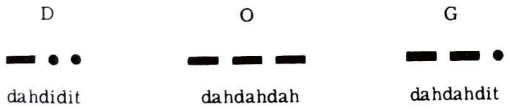
INTERNATIONAL MORSE CODE

International Morse Code is shown below and on the fold-out from Page 163 in dots and dashes for each letter and number. It is also shown in the phonetic form, as each letter and number actually sounds. Try to learn a few letters of the code at a time. After you have memorized the code, you will find it necessary to recognize the sound of each letter in code to build up your code speed.

Each dot is normally referred to as having the sound "dit," and each dash is referred to as "dah." Note that the "dahs" and "dits" are run together, like one word for each character, since this is how they will sound when sent properly.

Spaces come between the letters, with longer spaces between the words. The space between words should be about 5 times greater than the space between letters.

Examples: The word "dog"



NOTE: In the following example, the space between the words is five times greater than the space between the letters.

HOW TO LEARN MORE ABOUT ELECTRONICS

This Electronic Workshop has introduced you to the fascinating world of electronics. It can't teach you all about electronics, but it might give you a strong desire to go further. Here are some ways to learn more:

- The Heath Company has an Educational Series of text books and kits, such as: Basic Radio, Models EK-2A and EK-2B; Basic Transistors, Model EK-3; and others. These teach you electronic fundamentals while you have the fun of kit building and experimenting. You also finish each book with a useful device, like a radio or meter. See your Heathkit Catalog.

- Check with your local schools about electronics courses or a radio club.

- For more information about amateur radio, write to the American Radio Relay League; Newington, Conn. 06111.

- Several magazines are available for electronic hobbyists at your local newsstand. Some of these may be too complicated for you, but others are not. They might even give you ideas for additional things you could build with your Workshop.

Check at your local library. Many good books are available for beginners in Electronics. Some of these books are listed below.

OTHER BOOKS TO READ

The books listed below contain information on basic electricity, electronics, and on amateur radio theory, rules, and practices.

Epstine, Sam and Beryl. The First Book of Electricity (found in the First Book Library for Boys and Girls, New York, Greystone Press).

Meyer, Jerome S. Picture Book of Electricity, New York, Lothrop, Lee, and Shepard Co., Inc.

Stoddard, Edward. The Real Book of Electronics, New York, Garden City Books.

Yates, Raymond F. The Boys Book of Communication, New York, Harper and Brothers.

ARRL, Radio Amateurs Handbook. American Radio Relay League, West Hardford, Connecticut.

Merit Badge Pamphlets on Radio, Electricity, and Electronics, Boy Scouts of America.

THE CONTINENTAL (INTERNATIONAL) MORSE CODE

A	● ▬	didah	N	▬ ●	dahdit
B	▬ ● ● ●	dahdididit	O	▬ ▬ ▬	dahdahdah
C	▬ ● ▬ ●	dahdidahdit	P	● ▬ ▬ ●	didahdahdit
D	▬ ● ●	dahdidit	Q	▬ ▬ ● ▬	dahdahdidah
E	●	dit	R	● ▬ ●	didahdit
F	● ● ▬ ●	dididahdit	S	● ● ●	dididit
G	▬ ▬ ●	dahdahdit	T	▬	dah
H	● ● ● ●	didididit	U	● ● ▬	dididah
I	● ●	didit	V	● ● ● ▬	didididah
J	● ▬ ▬ ▬	didahdahdah	W	● ▬ ▬	didahdah
K	▬ ● ▬	dahdidah	X	▬ ● ● ▬	dahdididah
L	● ▬ ● ●	didahdidit	Y	▬ ● ▬ ▬	dahdidahdah
M	▬ ▬	dahdah	Z	▬ ▬ ● ●	dahdahdidit

1	● ▬ ▬ ▬ ▬	didahdahdahdah	6	▬ ● ● ● ●	dahdidididit
2	● ● ▬ ▬ ▬	dididahdahdah	7	▬ ▬ ● ● ●	dahdahdididit
3	● ● ● ▬ ▬	didididahdah	8	▬ ▬ ▬ ● ●	dahdahdahdidit
4	● ● ● ● ▬	dididididah	9	▬ ▬ ▬ ▬ ●	dahdahdahdahdit
5	● ● ● ● ●	dididididit	0	▬ ▬ ▬ ▬ ▬	dahdahdahdahdah

Period	● ▬ ● ▬ ● ▬	didahdidahdidah
Comma	▬ ▬ ● ● ▬ ▬	dahdahdididahdah
Question Mark	● ● ▬ ▬ ● ●	dididahdahdidit
Error	● ● ● ● ● ● ● ●	dididididididit
Double Dash	▬ ● ● ● ▬	dahdidididah
Wait	● ▬ ● ● ●	didahdididit
End of Message	● ▬ ● ▬ ●	didahdidahdit
Invitation to Transmit	▬ ● ▬	dahdidah
End of Work	● ● ● ▬ ● ▬	dididahdidah
Fraction Bar	▬ ● ● ▬ ●	dahdididahdit

SPECIFICATIONS

Number of Experiments.	35.
Typical Experiments.	Code Flasher Public Address Amplifier Intercom Loudspeaker Code Oscillator Electronic Organ Burglar Alarm Metronome Siren 4-Transistor Receiver Voice Transmitter
Power Requirements.	4 type D cells (batteries not supplied).
Color.	White steel frame with red and white experimenter board.
Dimensions.	Experimenter Base: 15-3/4" wide x 12" deep x 4" high (with all parts installed). Remote Station: 5" wide x 5" deep x 3-3/8" high.
Net Weight.	7-1/2 lbs (including the storage carton).

The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

REPLACEMENT PARTS PRICE LIST

To order parts, use the Parts Order Form furnished with this kit. If Parts Order Form is not available, refer to Replacement Parts in the Kit Builders Guide.

PART No.	PRICE Each	DESCRIPTION
RESISTORS		
1-83	.10	56 Ω
1-6	.10	470 Ω
1-7	.10	680 Ω
1-9	.10	1000 Ω
1-16	.10	4700 Ω
1-73	.10	8200 Ω
1-20	.10	10 kΩ
1-22	.10	22 kΩ
1-26	.10	100 kΩ
1-27	.10	150 kΩ
1-30	.10	270 Ω
CAPACITORS		
21-140	.10	.001 μF
21-46	.10	.005 μF
21-16	.10	.01 μF
21-31	.10	.02 μF
21-48	.15	.05 μF
27-47	.20	.1 μF
25-54	.20	10 μF
25-56	.40	100 μF
26-67	1.35	Tuning capacitor

PART No.	PRICE Each	DESCRIPTION
OTHER CIRCUIT COMPONENTS		
417-118	.40	Transistor (type 2N3393
9-6	.90	LDR
401-36	.65	Earphone
40-984	.85	Antenna coil
19-83	.95	Control
60-2	.30	Switch
75-52	.10	Switch insulator
69-15	2.85	Relay
401-137	2.50	Speaker
407-116	3.00	Meter
412-1	.15	Lamp
434-21	.10	Socket
CHASSIS PARTS		
200-544	.85	Remote chassis
202-83	.55	Front panel
202-84	.65	Rear panel
202-85	.50	Side panel
204-922	.10	Meter bracket
204-946	.55	Battery bracket
86-18-1	.90	Circuit board

HARDWARE

PART No.	PRICE Each	DESCRIPTION
250-182	.05	2-56 x 1/4" screw
250-175	.05	2-56 x 3/8" screw
252-51	.05	2-56 nut
250-172	.05	3-48 x 3/8" screw
252-1	.05	3-48 nut
254-7	.05	#3 lockwasher
250-89	.05	6-32 x 3/8" screw
250-56	.05	6-32 x 1/4" screw
250-162	.05	6-32 x 1/2" screw
250-170	.05	#6 sheet metal screw
252-3	.05	6-32 nut
252-22	.05	#6 speednut
254-1	.05	#6 lockwasher
250-52	.05	4-40 x 1/4" screw
253-1	.05	Fiber flat washer
253-2	.05	Fiber shoulder washer
252-7	.05	Control nut
253-10	.05	Control washer
253-6	.05	Large fiber washer
212-14	.10	Jumper strip
258-47	.05	Lug connector spring

MISCELLANEOUS

PART No.	PRICE Each	DESCRIPTION
100-849	1.50	Wire pack
207-19	.10	Cable clamp
258-37	.25	Key
258-38	.05	Connector spring
258-43	.05	Battery spring
263-7	.05	Felt foot
462-17	.15	Pointer knob
462-105	.10	Knob
490-25	.15	Screwdriver
490-5	.10	Nut starter
	2.00	Manual (See front cover for part number.)

The above prices apply only on purchases from the Heath Company where shipment is to a U.S.A. destination. Add 10% (minimum 25 cents) to the price when ordering from an authorized Service Center or Heathkit Electronic Center to cover local sales tax, postage and handling. Outside the U.S.A. parts and service are available from your local Heathkit source and will reflect additional transportation, taxes, duties and rates of exchange.